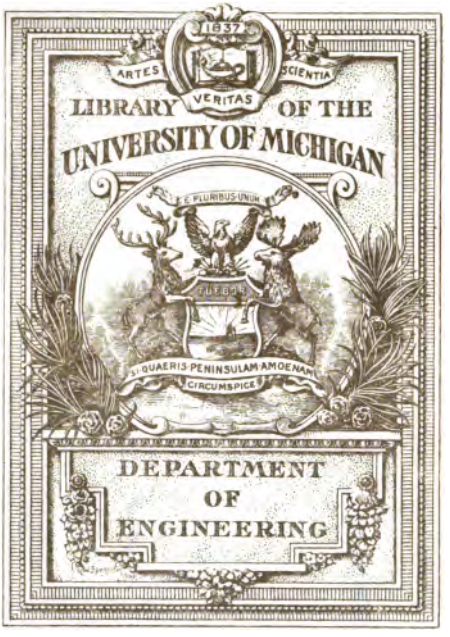
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PROCEEDINGS

OF THE

ASSOCIATION OF MUNICIPAL AND SANITARY ENGINEERS AND SURVEYORS.

VOLUME IX.—1882-83.

EDITED BY

THOMAS COLE,

ASSOC. M.I.C.E.

(*Secretary of the Association*).

The Association is not as a body responsible for the facts and opinions advanced herein.

LONDON:

E. & F. N. SPON, 16, CHARING CROSS.

NEW YORK:

35, MURRAY STREET.

1883.

LONDON:
PRINTED BY WILLIAM CLOWES AND SONS, LIMITED,
STAMFORD STREET AND CHARING CROSS.

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Ipswich	E. Buckham.
Kidderminster	A. Comber.
Kings Norton	R. Godfrey.
Kirkleatham	J. Howcroft.
Lancaster	A. Creer.
Leeds	T. Hewson.
Leek	T. Frost.
Leicester	J. Gordon.
Leigh, Lancashire	G. Dickenson.
Lewes	A. Holt.
Leyton, E.	W. Dawson.
Lincoln	R. A. MacBrair.
Littleborough	F. H. Shuttleworth.
Liverpool	C. Dunscombe.
"	G. F. Deacon.
"	J. H. Smethurst.

Liverpool	J. P. Wilson.
Llandudno	T. T. Marks.
Loftus, Saltburn-by-the-Sea	T. W. Stainthorpe.
Longton	A. Hardwicke.
Lowestoft	R. H. Inch.
Luton, Bedfordshire	W. H. Leete.
Macclesfield	J. Wright.
"	H. S. Aspinwall.
Maidstone	F. J. C. May.
"	J. S. Anscomb.
Malton	J. L. Webster.
Manchester	J. Allison.
"	S. C. Trapp.
"	R. Vawser.
"	A. M. Fowler.
Market Harboro'	E. G. Mawby.
"	J. W. Witts.
Merthyr Tydfil	S. Harpur.
Middlesbrough	E. D. Latham.
Middleton	W. Welburn.
Milverton	G. F. Smith.
Morpeth	T. W. Middlemiss.
Nelson-in-Marsden	W. Dent.
Newcastle-on-Tyne	W. G. Laws.
"	J. P. Spencer.
Newcastle-under-Lyme	J. Pattison, Jun.
Newton-in-Makerfield	R. Brierley.
Northampton	J. H. Pidcock.
North Bierley	J. Cook.
Oldbury	J. Devis.
Oldham	A. Foote.
Oswestry	E. B. Smith.
Over Darwen	W. Stubbs.
Oxford	W. H. White.
Plymouth	R. Hodge.
Portsmouth	H. P. Boulnois.
Prescot	W. Goldsworth.
Reading	A. W. Parry.
Redditch	T. W. Baylis.
Reigate	J. H. C. B. Hornibrook.
Rhyl	Robt. Hughes.
Richmond	F. S. Brunton.
Rochdale	S. S. Platt.
Rochester	W. Banks.
Ryde	F. Newman.
Sale	A. G. McBeath.
Sheerness	H. W. Stringfellow.
Sheffield	R. Davidson.
Shrewsbury	G. J. Butler.
Skipton	A. Ramsden.
Southampton	J. Lemon.
Southport	W. Crabtree.
South Shields	M. Hall.
South Stockton	S. E. Thorrold.
Sowerby Bridge	H. Whitlow.

Stafford	W. Blackshaw.
Stapleton	J. P. Curtis.
Stockton-on-Tees	J. Hall.
Stoke-on-Trent	W. Bowen.
Stratford-on-Avon	A. T. Davis.
„ „	T. T. Allen.
Stretford	H. Boyle.
Stroud	J. P. Lofthouse.
St. Helens, Lancashire	J. Hart.
St. Thomas, near Exeter	S. Churchward.
Sunderland	R. S. Rounthwaite.
Swansea	E. Cousins.
Swinton, near Rotherham	J. C. Haller.
Teddington	T. Goodchild.
Tewkesbury, Gloucestershire	W. H. Gray.
Tiverton, Devon	Wm. Rowe.
Todmorden	A. Greenwood.
Tonbridge	W. Noot.
Toxteth Park, Liverpool	J. A. Hall.
Tranmere	W. A. Richardson.
Tunstall	A. R. Wood.
Tynemouth	C. T. Gomoszynski.
Ventnor	R. S. Scott.
„	J. G. Livesay.
Wakefield	R. Porter.
Wallasey	J. T. Lea.
Wallsend	P. W. Thomson.
Walthamstow	G. B. Jerram.
Wanstead	J. T. Bressey.
Warminster	T. Cruse.
Warwick	E. M. Richards.
Waterloo, Liverpool	R. Thompson.
Watford	C. C. Lovejoy.
Wednesbury	J. W. Fereday.
Wellingborough	E. Sharman.
West Bromwich, Staffordshire	J. T. Eayrs.
West Derby, Liverpool	E. H. Allies.
West Ham, London	L. Angell.
Weymouth and Melcombe Regis	W. B. Morgan.
Whitehaven	R. Pickering.
Whitley	R. A. Worswick.
Whitworth	Thos. Holt.
Willesden	O. C. Robson.
Willington Quay, Northumberland	P. W. Thomson.
Windsor	T. V. H. Davison.
Withington	J. Swarbrick.
Wolverhampton	G. E. Thoms.
Woodford	J. D. Hooper.
Worksop	J. Allsopp.
Wrexham	J. W. M. Smith.
„	A. S. Jones.
York	W. G. Penty.

RULES OF THE ASSOCIATION.

I.—That the Society be named the "ASSOCIATION OF MUNICIPAL AND SANITARY ENGINEERS AND SURVEYORS."

II.—That the objects of the Association be—

a. The promotion and interchange among its Members of that species of knowledge and practice which falls within the department of an Engineer or Surveyor engaged in the discharge of the duties imposed by the Public Health, Local Government, and other Sanitary Acts.

b. The promotion of the professional interests of the Members.

c. The general promotion of the objects of Sanitary Science.

III.—That the Association consist of Civil Engineers and Surveyors holding chief permanent appointments under the various Municipal Corporations or Sanitary Authorities within the control of the Local Government Board, and such Honorary Members as shall be elected by the Council. Members who cease to hold such appointments after the Annual Meeting of the Association in 1881 are eligible for re-election by the Council, but will be disqualified from holding any office.

IV.—That the Affairs of the Association be governed by a Council, consisting of a President, Three Vice-Presidents, Twelve Members, and an Honorary Secretary, to be elected annually. The Past Presidents and the District Secretaries for the time being shall also be Members of the Council.

V.—That the Council shall nominate one name for President, six for Vice-Presidents, one for Hon. Secretary, and forty Ordinary Members from which to elect the Council. Such Nominations shall be printed and sent to each Member of the Association not less than fourteen days previous to the Annual Meeting. Every Member shall be entitled to vote for or erase any of such Nominations, or substitute other names, subject in all cases to the limits of Rule IV., and return the same within seven days from the date of issue. Such ballot papers shall be examined in London by the President, Secretaries and two Scrutineers appointed at the previous Annual Meeting, or by any two of the aforesaid Members.

VI.—That the Association be formed into District Committees which shall include the whole of the Members. Such Committees shall meet from time to time, in convenient centres, for the discussion of matters of local and general interest connected with the Association. Each District Committee shall appoint a Local Secretary, who will keep records of local proceedings, and communicate with the Council. No District Committee or Local Secretary shall be entitled either to represent or act on behalf of the Association.

VII.—That a General Meeting and Conference of the Association shall be held annually in such towns, in rotation, as may afford convenient centres for assembling the Members.

VIII.—That an entrance-fee of One Guinea, and a subscription of One Guinea per annum, from Civil Engineers and Surveyors under Rule III., shall constitute Membership of the Association.

ASSOCIATION OF MUNICIPAL AND SANITARY ENGINEERS AND SURVEYORS.

TENTH ANNUAL MEETING.

OXFORD, *June 28th, 29th, and 30th*, 1883.

GENERAL BUSINESS.

THE Members assembled in the Council Chamber, at Oxford Town Hall, when Mr. C. Jones, President, took the chair. The Minutes of the Annual Meeting held in London in June 1882 were first read, confirmed, and signed.

The SECRETARY then read the Annual Report for the year ending April 30th, 1883.

ANNUAL REPORT.

The Council have much pleasure in again presenting their Annual Report, and specially congratulate the Members on the increasing and successful progress of the Association during the past year.

Since the last Annual Meeting, which was held in London in July 1882, four District Meetings have been held: at Tynemouth, on the 27th September; at Llanwddyn, on the 25th October; at Rochdale, on the 16th March; and at Middlesborough, on the 23rd June. These District Meetings continue to maintain their popularity and to infuse more and more energy into the practical working of the Association.

The visits in connection with these meetings, to the various interesting works, have proved an important and highly valuable feature, and continue to be warmly appreciated by the Members.

These facts are satisfactorily proved by the numbers attending,

by the interesting papers of high technical value, and the well sustained discussions that followed them.

The Council have the satisfaction of announcing that sixteen new Members have joined the Association during the past year. Four Members have resigned, four have been written off, the letters addressed to them having been returned marked "No address"; and regret to have to report the deaths of four Members, viz. Messrs. J. S. L. Downie, of Skelton; George Thompson, of Derby; W. J. Boys, of Walsall, and J. G. Lynde, of Manchester.

The number of Members on the role of the Association at the close of the year was 5 Honorary Members, 210 Ordinary Members, making 215 in all.

The Council trust that each Member will use his best endeavour to augment this steadily increasing total, as the efficiency of the Association will be materially advanced by increased numbers.

In accordance with the Rules of the Association, the Ballot lists were issued with the result that the following gentlemen have been elected to the Council:—

President.—W. H. White.

Vice-Presidents.—J. Lobley, A. W. Parry, and R. Vawser.

Ordinary Members of Council.—H. P. Boulnois, E. Buckham, R. Davidson, Jos. Gordon, T. Hewson, S. Harpur, H. U. McKie, W. G. Laws, J. Proctor, G. E. Thoms, T. C. Thorburn, and T. Walker.

General Honorary Secretary.—Chas. Jones.

Treasurer.—Lewis Angell.

The satisfactory state of the Association is borne out by the accompanying duly audited balance sheet of the financial year, showing a balance in hand on the 30th of April of 126*l.* 18*s.* 4*d.*

The amount in hand on same date in the previous year is 106*l.* 10*s.* 3*d.*

The statement of assets and liabilities goes also to show the sound financial position of the Association.

The Council have had before them the consideration of several towns as suitable centres to hold the next Annual Meeting, and recommend that Newcastle-on-Tyne should be selected for the next Annual Meeting of the Association.

The President moved and Mr. Pritchard seconded the adoption of the Report.

Mr. Jerram expressed regret that no District Meeting had been

held last year in the Home Counties. Had meetings been held they should have obtained more Members, and the Council should offer some explanation. He also criticised the mode of electing the Council, and argued that the Council should not merely select twenty-two names, but that every Member of the Association should be eligible. A discussion ensued, in the course of which it was explained that the convening of District Meetings rested with the District Secretary. As to the mode of electing the Council, the model of the Parent Society, the Institution of Civil Engineers, and the Association of British Architects, had been followed; but a proposition would be submitted to that Meeting for altering the present mode of electing the Council.

Eventually the Report was unanimously adopted.

Mr. A. W. Parry (Reading) and Mr. T. Dawson (Leighton) were appointed auditors for the ensuing year.

Mr. Walker (Croydon), Mr. Holt (Lewes), Mr. Goodchild (Teddington), and Mr. De C. Mead (Hornsey), were appointed scrutineers for the ensuing year.

Mr. Vawser then submitted a proposition for altering the mode of electing the Council. He sympathised to a large extent with the complaints which had been made against the present system, and thought that the election of the Council should be as much in the hands of the Members as possible, and considered that the statement of attendances as at present given was objectionable. He proposed to amend Rule V. to read as follows:—

V.—"That the Council shall nominate one name for President, six for Vice-Presidents, one for Hon. Treasurer, and one for Hon. Secretary. Such nominations shall be printed and sent to each Member of the Association not less than fourteen days previous to the Annual Meeting. Every Member shall be entitled to vote for or erase any of such nominations, or substitute other names, subject in all cases to the limits of Rule IV., and return the same within seven days from the date of issue. There shall likewise be issued to the Members, and be returnable by them on the same days as aforesaid, a list of Members qualified to act as Members of the Council, and every Member shall be entitled to vote for any eighteen or less number of names on such list as Members of the Council, and the twelve Members having the highest number of votes for the Council (and

not being otherwise Members of the Council) shall, together with the elected officers of the Association, form the Council for the ensuing year. The voting papers and ballot list shall be examined in London by four scrutineers to be appointed at the previous Annual Meeting; and failing them, by the Members of the Council present at a meeting of the Council specially convened for the purpose."

Mr. JERRAM seconded the proposition on similar grounds, and affirmed that it was not right that the Council should practically blackball any one they pleased and select their favourites. Mr. Eayrs, Mr. Spencer, and others supported the proposition.

Mr. LOBLEY admitted that a case had been made out for enlarging the area from which the Council is selected, but proposed as an amendment that forty names instead of only twenty-two shall be circulated amongst the Members for ballot.

Mr. CARLTON seconded the amendment.

On being put from the chair, Mr. Lobley's amendment for increasing the number of names sent out at the ballot from twenty-two to forty, was carried by a majority of five.

Mr. ANGELL then moved "that no new rule or alteration of any existing rule be made unless notice of motion for such purpose and the proposed resolution thereon be sent to the Secretary at least three months before the Annual Meeting, and such notice of motion and resolution shall be printed in the Agenda for such Annual Meeting." He objected strongly to any such important change being made in the constitution of the Association when only about a quarter of the Members were present, and the rest had not had any notice of it whatever.

Mr. JERRAM seconded the motion, and it was carried unanimously.

Mr. JONES, after speaking of the gratification it had afforded him to occupy the post of President of the Association, and acknowledging the courtesy and cordiality with which he had always been received, introduced the President-elect for the current year, Mr. W. H. White, M. Inst. C.E. who was received with much applause. No Member of the Association, he said, was more generally or deservedly respected; he was confident he would render valuable services to the Association during his year of office.

Mr. JONES then vacated the chair.

Mr. W. H. WHITE, of Oxford, having taken the Presidential chair, briefly acknowledged the honour conferred upon him by placing him at the head of the Association, and hoped that his year of office would be a successful and prosperous one.

Mr. SPENCER then moved, in highly complimentary terms, a vote of thanks to the retiring President, Mr. Jones, for his services during the past year. He had discharged his duties admirably, and had evinced the greatest kindness and courtesy to every Member.

Mr. VAWSER seconded the proposition, which was carried by acclamation; and the ex-President in acknowledging the compliment said he had done his best and was gratified that his efforts had been appreciated.

The PRESIDENT then read his inaugural address.*

CHAS. JONES, *Hon. Sec.*
THOMAS COLE, *Secretary.*

* This address and the papers read at the meeting will be found at the end of the volume.

Dr. STATEMENT OF RECEIPTS AND EXPENDITURE FOR THE YEAR ENDING APRIL 30TH, 1883. Cr.

RECEIPTS.	£	s.	d.
To Balance at Bank (May 1st, 1882)	106	10	3
„ Entrance Fees	16	16	0
„ Subscriptions	185	17	0
„ Arrears	6	6	0
„ Publisher's Sale of Proceedings	16	7	3
„ Subscription paid in advance	2	2	0
	£333	18	6

EXPENDITURE.	£	s.	d.
By Sunderland Meeting	3	6	6
„ Messrs. Cook and Hammond—1st Account	11	13	6
„ „ „ 2nd „	7	10	6
„ Tynemouth Meeting	3	5	6
„ Annual „	15	12	0
„ Messrs. Clowes (Printing vol. viii.)	100	19	6
„ Llanfyllen Meeting	1	8	6
„ Secretary's Salary	45	0	0
„ Petty Cash—Stationery, &c.	3	17	11
Postage, General	3	0	7
do. Circulars	4	8	0
do. vol. viii.	4	9	2
Balance in hand	2	4	4
„ Bank charges for postages, &c.	0	4	2
„ Balance at Bank	126	18	4
	£333	18	6

STATEMENT OF ASSETS AND LIABILITIES, APRIL 30TH, 1883.

LIABILITIES.	£	s.	d.
To Estimated Liability on vol. ix.	30	0	0
„ Sundry Printing	5	0	0
„ Outstanding Accounts	0	0	0
„ Secretary's salary to Lady-day	15	0	0
„ Balance	136	19	9
	£186	19	9

ASSETS.	£	s.	d.	£	s.	d.
By Balance at Bank				126	18	4
„ Subscriptions in Arrear	£57	15	0			
„ „ less 50 per cent. bad ..	28	17	6	28	17	6
„ Proceedings in Stock	£57	19	6			
„ „ less 50 per cent.	28	19	9	28	19	9
„ Balance of Petty Cash in hand of Secretary				2	4	2
				£186	19	9

Examined and found correct, ALBERT W. PARRY, WM. HY. WHITE, } *Auditors.*

CHAS. JONES, *Hon. Secretary.*
THOMAS COLE, *Secretary.*

DISTRICT MEETING AT TYNEMOUTH,

September 27, 1882,

Held in the Council Chamber, Saville Street, North Shields,
Mr. J. G. LYNDE, *Past President, in the Chair.*

THE minutes of the last meeting were read and confirmed, after which it was resolved to adjourn the further discussion of Mr. Hall's paper on "Private Improvement Apportionments" to the next Northern District Meeting.

The following paper was then read and discussed:—

THE OPERATION OF THE CANAL BOATS ACT.

BY E. C. BUCHANAN TUDOR, ENGINEER AND SURVEYOR TO THE LOCAL BOARD, GOOLE.

THIS registration district—comprising the Navigation of the Humber, the rivers Trent and Ouse, the Dutch river, and the Goole and Knottingly Canal—is one of the most important, and as regards the number of canal boats passing through the district, probably the second in the kingdom.

Malton and York in the north, and Lincoln and Newark in the south, mark the limits to which these canal boats ply, whilst Sheffield, Barnsley, Huddersfield, Bradford, and Leeds lie to the west of an intricate network of canals, ramifying through the coal measures of South Yorkshire, and the Barnsley and West Riding districts, the extensive fields of building and flag stone, taking traffic from nearly all the populous towns, and uniting their streams for outlet by the river Aire and the Goole and Knottingly Canal into the Ouse, and the Keadby Canal into the Trent.

When the Act of 1877 came into operation there were upwards of 1000 boats, commonly called keels, trading through the port of Goole, the whole of which were used as dwellings and required registration.

In the year 1879, 520 were surveyed and registered by myself and after certain alterations received certificates, and at the close of 1880 the number had risen to 564, not including those registered at Driffield, Hull, Mirfield, Leeds, or Doncaster. There still remain a number used as habitations requiring examination and registration, which avoid coming within the district at such times when they may be called upon to show their certificate, and thus escape the observation of the inspector, where one is appointed as well as an examining officer.

There has been no general unwillingness to obey the law, and by the use of a little *tact*, much information as to canal life may be obtained.

When surveys have been made and requirements pointed out by me as a surveyor and examining officer under the Act, as a rule, they have been attended to, and on the whole fairly executed; only where poverty has been pleaded and existed, and in one or two exceptional cases, has there been any resistance to the authorities or tardiness in obeying the requirements. Indeed captains and their wives very often are desirous for the beneficial changes, whilst they are prevented representing their need, from fear of offending owners unwilling to expend money on their ships.

The Aire and Calder Navigation have used their great influence in the Goole district towards furthering the operation of the Act and have materially conduced to its effective working. In most cases it was found, when first surveyed, that alterations had to be made in the boats to meet the requirements of the Act, and I venture to suggest that more extensive ones than even the Act requires would be attended with good results.

The cabin space was almost in every case too small for the number of people inhabiting it; the means, if any, adopted for ventilation insufficient, and the arrangements of the fittings defective.

The sleeping accommodation was rarely indeed what could be desired, or deemed even decent, and frequent occurrences of overcrowding and cohabiting prevailed.

The most suitable of any of the cabins for human habitation were those on vessels devoted to the carrying of ammoniacal liquor, these being placed on deck; but before this had been adopted the evil and danger of defective ventilation had been shown by the death of several people, who were asphyxiated in one of the beneath-deck cabins, by the vapours, which filled the place in which they slept, having had no means of exit. I would not say it is

practicable to put all cabins on deck, as they would prevent a passage through low bridges or tunnels. I have observed in Salop and Staffordshire, men, women, and children, lying on their backs pushing boats through tunnels. In many of these districts there are no other means of propulsion available, or any steam tugs of which the chimneys can be lowered.

The Aire and Calder Navigation have powerful steam tugs between Goole, Leeds, and Barnsley, and I have frequently seen 10 or 12 keels fastened to one tug, representing 800 or 900 tons, travelling at the rate of 4 or 5 miles an hour including stoppages. I only wish this system was general, whereby frequent cruelty to horses from boat hauling would be avoided, and many poor foot-sore children would escape the brutality they often meet with. Since the application of the Canal Boats Act, very great improvements have been introduced into the structure and contrivance of these dwelling places, but there are still defects existing even under the working of the Act, to which I wish to refer.

The floors and sides of the cabin are frequently found so far defective as to allow moisture and noxious vapours from the bilge to penetrate, and to make the beds and the other lockers musty, damp, and offensive.

I am of the opinion that great attention should be paid to the state of the linings with regard to this danger, and that suitable linings, having a ventilating cavity, would be of great advantage.

So also with regard to the bulkheads separating the cabin from the cargo where cabins are below deck, if hollow bulkheads were universally carried water-tight to the bottom of the hold, not only would the living places be kept drier in case of carrying a wet cargo, but better ventilation might be secured, and greater comfort and safety, when carrying noxious goods, such as decomposed and fermenting shoddy, scutch manure, bones, hides, and even in some cases rotting fish. After, as well as at the time of the carriage of this description of cargo, I am persuaded that no little danger to health is incurred, where provision has not been made to obviate it.

The boat laden with dung or other offensive and wet substance, if of wood, has her timbers partially soaked with the liquor oozing from the cargo, and the bulkheads separating it from the cabins may be saturated, and long after the boat has been discharged the fermenting moisture may be emitting a poisonous vapour into the bed or food lockers or other inhabited part adjoining the hold.

The bulkheads of vessels chiefly carrying this kind of cargo might be lined with suitable cement or metal, or otherwise protected from the infiltration of offensive liquid, and I think that, more especially in new boats hereafter to be built, they should always be continued to the bottom and sides of the boat, forming a water-tight section.

It would also be a useful precaution if under the wooden floor of the cabin there was required to be laid a cement or concrete floor, cutting off all emanations and vapours which might rise. Provision should be made for the ventilation of bilges.

The Act requires that the cabin should have all painted surfaces thoroughly cleansed and renewed once in every *three* years, but considering the purpose for which some of them are used this would be better done as frequently as the examining officer or inspector finds it necessary.

I may here mention that in several instances where the captain has been the owner of the boat great taste for cleanliness has been displayed, also in decorations, bright chimney ornaments and painted panels on lockers of flowers or landscapes, and in some instances ferns are grown in these homes, lending a very pleasing appearance. Owners of such boats as these frequently have homes ashore, and the children are sent to school.

The bedding in these confined spaces has always a tendency to become damp and stuffy, and I think that any regulations that would prevent the bed flooring being a fixture would be an advantage; it should be made to take out or turn up. The mattresses ought to be more frequently removed, and the bed-clothing aired before being replaced. Anything which will secure this being done is beneficial. Communication between bed-locker and bilge is very objectionable, as any casual oscillation of the vessel would stir up the stagnant liquid in leaky ships, and the gases be sent direct to the sleeping or living compartments, berths, &c.

I think bed-lockers require special consideration, and an effectual method of ventilating these sleeping places would do much to secure a more healthy condition to the inmates.

Although the air space required by the Act is by no means excessive, it is very often found to be diminished by the measurement of that occupied by the fittings, *as clear air space*, and this is very frequently aggravated by unauthorised additions to the furniture or clumsy alterations of that already fixed after inspection. I have not unfrequently met with close sliding or folding doors to

the bed-lockers, and am of opinion that they should not be allowed unless special and ample provision were made (as I have said before) for the efficient ventilation of the bed space. The doors of the lockers should not completely close the openings either at the top or bottom, in order that a circulation of fresh air may continue through the space and drive out the foul air at a suitable point when they are so closed, and this arrangement should also be adopted for other lockers which may contain food, &c.

Happily only two cases have come within my knowledge of infectious disease on board "canal boats" within the Goole district, but those of ordinary sickness have not been rare, and then the ordinary provision of clear air space seemed in many instances very insufficient, the usual occupants continuing to dwell and keep their food in the same cabin with the patient.

Both before the operation of the Act, and since it has been in force, instances of births occurring on board have come to my knowledge, and the inhabitants (of both sexes) still remaining and sleeping in their usual beds, little or no alteration being made in the usual arrangements, although for the sake of health and decency they were evidently required.

An instance which came to my knowledge immediately before the passing of the Act, will serve to show how necessary regulations had become from both moral and sanitary points of view:—On one of these boats, occupying the same small cabin, lived a man, his wife, and two adult unmarried daughters, and these latter had born in the cabin, at almost the same time, each an illegitimate child, the whole continuing to sleep as best they could in the one room. It transpired that when the parents were drinking, or on a "drunken bout" (a local phrase) at any of the various stations, these girls took charge of and navigated the boat, with such chance assistance as they could get on the way.

The provisions for the separation of the sexes made by the Act are difficult of enforcement, and the difficulty varies as the construction of the boat. Continual cases have come before my observation of their being infringed.

Of course a state of miscellaneous overcrowding is not so common now as it was previous to the application of the Act, but still it does occur and is difficult to entirely prevent under the existing arrangements.

The master's family is frequently increased, after his receiving his certificate, by the return "home" of some of the younger

members who were absent at the inspection of his boat; a visitor has been entertained, and actually cases of a lodger being taken in are not unknown. I have reason to believe that misdemeanants are sometimes hidden in these places.

Again, a new master may be put on board (and changes of owners and captains very frequently occur) who, having a larger family than the last *and making no report*, escapes the inspector.

The exercise of powers similar to those of the Lodging Houses Act, and occasional prosecutions for offences of these kinds, injurious to health and morality, would be likely to check or to put a stop to these practices. Instances have been known of the registration plate being changed.

When a change of captain occurs, a clause making it compulsory for him to report himself at his registration district, would be most useful.

Children bred and born in these floating homes, are with difficulty traced to any school of instruction, and indeed it is hard to see how this could be perfectly accomplished, as the boats travel from station to station, or from isolated landing places to pit loading stage, carrying their population with them, very little more easy of compulsion, so far as education goes, than any tribe of wandering gipsies. I shall at a subsequent period endeavour to cope with this existing difficulty.

The young on board many of these boats cannot escape the danger of being brought up without civilised instruction, exposed as they are to the influences of evil example, swearing, foul language, intemperance, prostitution (and if this be bad in a house, what must it be in the cabin of a boat?), and to frequent imposition of labour for which they are not always fitted.

The cabins of canal boats, from necessity in trade, are compelled to become the habitations of men and women, but it is to be deplored that they should ever be made the homes of *girls* or young children, and especially when these are of both sexes huddled together.

Perhaps as regards their education, matters might be improved, were the age and sex of every child required to be endorsed on the certificate (I have generally done this on those that came under my own hands) with a full statement, which could be verified, of the means provided for their instruction ashore, in accordance with the spirit of the Elementary Education Act.

Sunday sailing of course removes them from much chance of

religious training, nor can this be easily obviated so long as their home is "on board."

There is one other consideration necessary for the healthy and safe inhabiting of canal boats, as well as cleanliness, ventilation, and more abundant free air space, which has appeared to me to be in most cases a secondary consideration, if not entirely neglected, that is, the *ample supply of pure water* for the consumption of the crew, and when and from what source obtained. In many of these boats the barrels or receptacles they are compelled by the Act to carry are merely filled from the water in which they float, or leaky pump wells; and, in the neighbourhood of towns pouring sewage or dye water into canals and streams, in these days of sanitary reform, it is well known to what state of impurity every canal and river has arrived. There these boats have only

"Water, water, everywhere, and not a drop to drink."

Every man might have shot an albatross!

The barrels or tanks provided should be required to be filled as they pass from station to station at every pure supply, and I would suggest that on a sheet hung on the cabin, an entry should be made of the date and source of such supply.

Probably the most practical improvement on the present mode, would be the enforcement of a systematic and periodic inspection of boats, and the endorsement of certificates when required on report of arrival at an inspection station. Once a year at least, as in the case of passenger steam boats, these canal boats should be offered for inspection. A plan of the cabin, showing the position of the fittings, lockers, and bed places, should be sketched on the certificates, so that any alterations or encroachments on the free air space might be recognised by the examining officer.

It might perhaps be considered too stringent to require it, but I am persuaded that good results would follow were the captains of these boats required to report themselves, say once in every six months, so that if need be the examining officer might visit and examine the condition of the inhabited cabin or cabins.

A copy of the certificate and plan should be kept always on board, for the purview of the officer appointed, and one ought to be in the hands of the owner, who is responsible for any infraction of the regulations. But in the case of a company owning a number of boats, captains are frequently changed as much as three times a week for various reasons (this I know), therefore it would be

practically impossible to report on *every* change of master, but in these cases a company may hold captains, and be themselves held responsible for any infringement of the original certificate. It would be desirable that upon every change of master, an *endorsement* should be compulsory, so that the number of those likely to sleep on board, the members of his family and assistants, and the means adopted with regard to the education of the younger children might be known.

By far the majority of canal boats plying on the rivers and canals in this district are used as dwelling places, and it should therefore be the exception that one should pass through port or lock without the register plate affixed aft; if therefore a record were kept by the lock-keeper and entered on the pass note at the foot of each canal and reported to the registration authority of those vessels which are *not* authorised as habitations, the captains of such vessels would be aware that they were under surveillance, and not allowed to use their cabins for other purposes than that for which they are registered.

In my remarks on the structure of cabins I have omitted what I desire to suggest, that there should be some minimum height from the floor to the ceiling laid down for all new vessels.

The effective and beneficial working of the Act must always, to a certain extent, depend on the industry, zeal, and knowledge of those appointed to carry it out, and I wish to express the opinion that if these officials were appointed by Government for combined districts rather than by the Local Authorities, constant supervision would be maintained. The small salary to examining officers and the little importance placed on their duties by some district authorities, lead I fear in many cases to laxity, indifference, or a careless performance of inspection. No doubt the regulations are, to a certain extent, regarded as irksome, and any extension of powers might be looked on at first by owners as vexatious. Meanwhile the advantage grows, and the morals, manners, and health of a population of, it is reported, nearly 100,000 persons are remodelled and improved, and the next generation comes forward under better conditions, more decent surroundings, and in a somewhat purer mental, moral, and physical atmosphere.

DISCUSSION.

Mr. SPENCER: I have experienced great satisfaction in listening to the very excellent paper written by Mr. Tudor, and am only sorry that he is not present to reply to the discussion. Mr. Tudor has treated the subject not only from a sanitary, but also from a moral point of view. Of course, we have little or nothing to do with the latter aspect of the question, but as sanitary engineers we have a great deal to do with the former. There is nothing to show the condition of canal boats previous to the passing of the Act in 1877, but it is clear that the Act aimed at the root of the evils spoken of by Mr. Tudor, and was intended to improve the condition of the canal-boat people. Like other Acts, it is defective, and it has also been found difficult to carry out its provisions. Mr. Tudor suggests that the inspectors should be appointed by the Government instead of by every little authority through which the canals pass, and they should devote their whole time to the work, and have a certain portion of the canals assigned to each. Such appointments might be made by the Board of Trade, the inspectors to be under the control of that board. Such an arrangement might work well. Canals are rising in importance in spite of their having been kept down by the railway companies. There was a time when canals were bought up by the railway companies for the sole object of rendering them inoperative. But in spite of this, and in spite of the popular estimation in which railways are held, canals are not yet things of the past, and may again play an important part in trade. Therefore this is a subject well worthy the attention of our association and of the Government. It appears to me that the cabins of canal boats should be, to some extent at least, above deck, and if the Act specified the height it would be an advantage. If this is impossible on certain canals as things now are, such alterations should be made as are necessary. The paper deals with questions mostly affecting the owners of the boats, and the Act should compel them to so construct their boats as to conform to sanitary laws. It would be an improvement if there were two cabins—fore and aft,—each large enough to afford sleeping accommodation, but the after cabin larger than the other. I have no wish to detain you further, as the time is short, and there

may be those present from canal districts who have something to say.

Mr. McKie: The paper has been written with a great deal of thought. But is it a fit subject for us as Municipal and Sanitary Engineers to discuss? I think it is altogether outside our province. If it is in our province, it only affects such of us as are inspectors as well as engineers and surveyors. It does not affect us as engineers, and it is matter for consideration how far it should take up the time of the meeting. At the same time, every credit is due to Mr. Tudor for his excellent paper.

Mr. Pritchard: It is a very able paper, and Mr. Tudor deserves the thanks of the Association for bringing it forward. Mr. McKie is at a loss to know what the subject has to do with us, but if many of us are inspectors as well as engineers and surveyors, it is quite permissible, and a proper subject for discussion.

Mr. McKie: Why not lay it before the Inspectors' Association?

Mr. Pritchard: I cannot quite see the necessity for having Government inspectors, especially when we have such able men as Mr. Tudor. No Government inspector could be more efficient.

Mr. McKie: Government might employ inspectors for the whole lengths of canals.

Mr. Spencer: Or for distances of from six to eight miles.

Mr. Jas. Hall: Why not employ the river police? there can be no difficulty in the way.

Mr. McKie: If the inspectors be the surveyors to the local boards through whose districts the canals pass, how would they act? It would be far better to have one inspector for each canal, and not a large number of inspectors for one canal.

Mr. Lemon: There ought to be some regulation with regard to the height of bridges over canals, and a provision for their being raised where necessary.

Mr. Pritchard: I have much pleasure in moving that the best thanks of the Meeting be conveyed to Mr. Tudor for his very excellent paper.

Mr. Lemon: I have great pleasure in seconding it.

Mr. Pritchard: I have also great pleasure in moving a vote of thanks to the Mayor of Tynemouth for allowing us the use of the Guildhall for this meeting, and to the Town Clerk for his kind remarks in welcoming us to the borough.

Mr. McKie: I have much pleasure in seconding the motion.

The votes of thanks were carried by acclamation, and the meeting adjourned.

The Members afterwards visited the new Coble Dene Dock works and the pier works, under the kind conductorship of P. J. Messent, Esq., the Engineer to the River Tyne Commissioners. The party were conveyed from North Shields to the Coble Dene Docks in one of the Commissioners' steamboats, and on landing a saloon carriage was placed at their disposal. Mr. Messent accompanied the Members on their tour of inspection, giving every explanation and showing every courtesy. On re-embarking, the Members visited the pier works in the company of Mr. Messent, who hospitably entertained them. The company then landed at Tynemouth, where they dined together. Hearty votes of thanks were accorded to Mr. Messent and others connected with Tynemouth for their kind reception of the Members, and in the evening the Naval and Engineering Exhibition was visited.

DISTRICT MEETING AT THE SOURCE OF THE RIVER VYRNWY.

October 28th, 1882.

THE VYRNWY WATERWORKS.

The following general description of the Vyrnwy works is extracted from an account prepared on behalf of the Corporation of Liverpool, and published in connection with the ceremony of erecting the memorial stone at the commencement of the works on the 14th July, 1881 :—

"At a distance of six miles to the south-east of Bala Lake, over the well-known Bwlch-y-Groes Pass (the Pass of the Cross) there is a long, narrow tract of valley land, at an elevation of 780 feet above mean sea-level, scooped out of the rugged mass of Silurian rocks by which it is surrounded, and evidently at some period the site of a natural lake, not unlike in its dimensions that of Bala. A geological ordnance map (on which the alluvial bottom is distinctively coloured) shows the resemblance very clearly. Into this valley there flow innumerable rivulets and brooks, which have their rise chiefly on the eastern and south-eastern slopes of the Berwyn range of mountains, and which unite to form the river Vyrnwy. In the centre of this valley stands the little village of Llanwddyn, consisting of thirty or forty small cottages, chiefly occupied by shepherds and farm labourers, a small church, and two Nonconformist places of worship. At Llanwddyn the valley attains a width of over half a mile, and then, following the course of the river, becomes narrower, until at a distance of two-and-a-half miles below the village its width at the narrowest part is not more than about 300 yards. Across this gorge, through which the Vyrnwy runs, the Corporation intend to construct an embankment, the total length of which will be 418 yards, and the top of which, measured to the water-line, will be about 84 feet above the present valley bottom. The effect of erecting this short embankment will

be to dam back the river so as, without any further enclosure than the natural valley sides, to form a lake which will be four-and-three-quarter miles long, with a water area at the surface of about 1115 acres. The surface area of Bala Lake is 1100 acres. The contents of Lake Vyrnwy, above the level at which water will be drawn off for Liverpool, will be about 12,000,000,000 gallons, which is one-third more than the storage capacity of the Loch Katrine works of the Glasgow Corporation. The embankment is to be built of masonry, and will be the largest work of the kind in this country. It will be spanned by arches carrying a road and footways, having a total width of 17 feet between the parapet walls. Any overflow from the lake will pass through the central series of arches and down the outer face of the wall. Thus the costly and troublesome weirs and byewashes of ordinary earth embankments will be dispensed with. The greatest width of the embankment at the base will be over 100 feet. For the discharge of the compensation water which the Corporation are bound to supply to the river there will be two tunnel outlets, with necessary sluices and appliances, through the embankment.

"It is not intended in this sketch to do more than indicate the general features of works, the details of which will be more appropriately described when they have been carried out. The area of the watershed, from which water would naturally flow into Lake Vyrnwy is 17,583 acres, and it is from this area only that it is proposed to collect and impound water in the first instance, but, as the demands in Liverpool increase additional water will be brought into the lake from two streams called the Cowny and Marchnant, which now fall into the Vyrnwy below the proposed embankment. These streams will be brought into the lake by tunnels respectively $1\frac{1}{4}$ and $1\frac{3}{8}$ mile in length. The Cowny and Marchnant will give an additional contributing area of 4,417 acres, making the total watershed of the lake, when all the works contemplated by the Act have been carried out, 22,300 acres. The water to be thus collected will be of the usual excellent quality derived from the Welsh hills. Previous to the application to Parliament for the Water Act of last Session, the water was analysed under various conditions of flood and drought by Dr. Frankland, Dr. Tidy, and Dr. Brown. Their reports were of the most favourable character, though chemical evidence is scarcely necessary where, as in this case, the watershed is so admirably adapted for the collection of water in the purest and best possible condition for potable purposes.

There is probably no district in Great Britain of equal area that is so thinly populated. There are no mines or mineral workings, and the only dwellings remaining will be a few scattered sheep-farms. The hills are precipitous and sterile, and the slate rocks of which they are composed throw off the rainfall with great facility. The Vyrnwy has long been celebrated for the excellence, variety, and abundance of its fish. Pennant wrote that the river merited the title of *Piscosus Amnis* as much as any he knew.

"The aqueduct for conveying the water from Lake Vyrnwy to Liverpool will be formed partly by tunnelling and partly by cast-iron pipes. Where the aqueduct is in tunnel it will be made of sufficient capacity to convey as much water to Liverpool as the lake will be capable of yielding, but where pipes are to be used it is intended to lay, in the first instance, only one pipe, which will be large enough to deliver about one-third of the calculated total yield available for Liverpool from the watershed. The aqueduct will commence at the lake by a tunnel about seven feet in diameter and two-and-a-quarter miles in length, starting from the north side of the Vyrnwy valley, and terminating in the Hirnant valley. From the outlet of the tunnel a cast-iron pipe of about 42 inches internal diameter will be laid through the Hirnant valley across the river Tanat, and to the north of the village of Llanrhaiadr-yn-Mochnant, near which place the first section of the pipe line will terminate in a small reservoir or relieving tank to be constructed at Parc Uchaf. Thence it will be laid through the parish of Llansilin to the valley of Cynynion, on the borders of Denbigh and Salop counties, whence a tunnel of about one mile in length will be driven to the west side of the Morda valley. There will be a raised aqueduct over the Morda river, and from the east side a second tunnel of one mile long, terminating in a small reservoir to be formed on elevated ground about a mile to the west of Oswestry. At this point filter-beds are to be made if filtration should be required. From Oswestry the cast-iron main proceeds in a north-easterly direction through the parishes of Whittington and Ellesmere, Hanmer and Malpas. In Malpas there will be another relieving tank on Oat-hill. Thence the pipe will be continued through Bunbury and Beeston, passing at about a mile to the east of Tarporley, to a relieving tank on Luddington Hill; thence through Delamere Forest, and under the river Weaver, near Kingsley ford, through Aston, to a tower to be erected at Norton. From the Norton water-tower the main takes a northerly direction to the Mersey, which it crosses at a point

two-and-three-quarter miles to the east of the Runcorn viaduct. After crossing the Mersey the pipe follows an almost straight line through Farnworth and Rainhill to the existing reservoirs of the Corporation at Prescot, near Liverpool. The total length of the aqueduct from the Vyrnwy to Prescot is 67 miles, but the distance from the Vyrnwy to Liverpool in a direct line is only 46 miles.

"The River Vyrnwy is at present subject to great fluctuations in flow. After the lake has been made the Corporation will have to send down the river the statutory supply of compensation water, which, being delivered in a steady, regular, and constant stream, instead of the present irregular flow, will be a great improvement to the river, and a great advantage to the residents on its banks. The total estimated yield of Lake Vyrnwy watershed, including the compensation water, is estimated at 52 million gallons per day.

"The Engineers for the works are Mr. Thomas Hawksley, of London, and Mr. George F. Deacon, of Liverpool, under whose superintendence the drawings and specifications are to be made and the works to be carried out.

"When the works now being inaugurated have been finished, Liverpool will possess the finest supply of water of any city in the world. In the Rivington and Vyrnwy watersheds, and the new red-sandstone wells, the Corporation have the means of supplying a population of more than 2,300,000 with a constant supply of unexceptionable water. The population at present supplied by the Corporation according to the recent census, is 720,000. If it continues to increase as it has done during the last decade the population will, at the end of the present century, amount to more than a million. In addition to this the Corporation have agreed to supply water to the towns of St. Helens, Widnes, Warrington, and Oswestry as soon as the Vyrnwy water reaches Liverpool."

When the visit of the Association took place the building of the masonry embankment had already been commenced at the deepest part of the excavation for the foundations. The rock for a width of more than 100 feet had been exposed across the valley. It exhibited glacial smoothing and striations nearly parallel to the axis of the valley, and similar striations are observed at various points on both sides of the proposed lake to its head, nearly five miles beyond the embankment, and at even more distant places near the beds of tributary streams. It was stated by Mr. Deacon that the shafts, borings, and probings, made for the purpose of determin-

ing the best site for the embankment, had revealed the fact that higher up the valley as well as lower down, the rock became rapidly deeper. This circumstance and other geological observations point to the conclusion that the valley was scooped out of the rock by glacial action, probably, like many other glacial valleys, to a great depth. Near the site of the proposed embankment the glacier on its course down the valley was squeezed by the converging mountains to a comparatively small width, and coincidently, was prevented from wearing the bottom so rapidly and so deeply as higher up the valley, by bands of the hard volcanic rock known as Bala Ash. As the glacial age passed away, and the frozen streams became running water, the basin, scooped out by the glacier, must have become the site of a lake some 50 feet below the present level of the valley, this being the level of the rock near the embankment protected by "Bala Ash" over which flowed the ancient river from the lake. At this time the rigour of the glacial age had not all disappeared, denudation by frost and rain produced great effects in a short time, and, much sooner than would now be the case, the lake was silted up with gravel and sand brought down in flood by the tributary streams, and by the same agencies the valley has been filled up apparently almost level throughout its length, to a height of about 50 feet above the former lake. Through the alluvium and peat winds one of the principal tributaries of the Severn, the modern river Vyrnwy. Even now, however, in time of flood the valley assumes the aspect of a lake but little above which, on a delta at the mouth of the effluent river Cedig, stands the village of Llanwddyn. The level of the new lake, to be created by the presence of the great masonry embankment now being constructed, will be some 130 feet above that at which its ancient prototype probably lay.

The members present, after viewing the works, and especially the rubble masonry, in which stones up to 6 tons weight are being used, drove up the valley to an old farm-house near the head of the proposed lake, known as Rhiwargor, from the hill behind which a magnificent view down the valley was obtained. Hence the members drove to another branch of the valley, and visited Eunant Hall, an old shooting lodge, from which this remarkable, and hitherto almost unknown part of Britain was also viewed.

DISTRICT MEETING AT ROCHDALE,

March 16, 1883,

Held in the Town Hall, Rochdale,

Mr. R. VAWSER, *Vice President, in the Chair.*

THE MANCHESTER, BURY, AND ROCHDALE TRAMWAYS.

By R. VAWSER, M. Inst. C.E.

These tramways form a means of communication between several populous districts in the neighbourhood of Manchester, and unite with the Manchester tramway system at the several places shown on the Plan; they also form a complete system in themselves, and when complete will have a greater mileage than any other tramway system in the country: upwards of 44 miles of tramways are already authorised by Act of Parliament, and a further length of 11 miles is now before Parliament, and I expect this will be further increased during next session of Parliament.

A portion of the tramway between Manchester and Bury was opened for public traffic on the 12th March last, and in several other parts of the system the works are in progress, and very nearly completed. The mode of construction for the greater part of the road is shown upon the drawing before you. It consists of the Gowan rail, which was first used on a large scale in Manchester, where it has been a very great success. The rails weigh 93 lb. to the lineal yard, are 7 inches wide at the base and 3 inches on the top, and are 7 inches deep, thus forming a solid girder. They are of solid steel, and rest direct on a concrete bed, differing in that respect from the old form of tramway rails, which required support by timber or cast-iron sleepers.

About one-half of the line already opened, between Manchester and Bury, has been laid with Barker's rail; but it is intended to

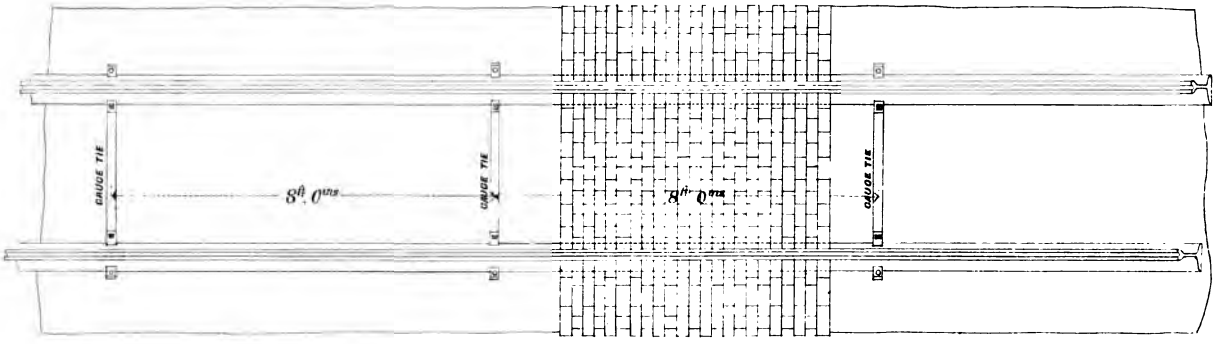
continue the use of the Gowan or girder rail throughout the remainder of the system.

This tramway line has been specially designed for steam traction, and it was considered advisable to use the strongest and best rail it was possible to get. These rails are very expensive and difficult to roll, as the groove on the top of the rail cannot be accurately formed in the rolling mill, but is cut out after the rails are partially formed in the mill.* The rails are fished with steel fish-plates, and when fixed are likewise secured by wrought-iron tie-rods placed 8 feet apart, as you will see upon the drawings. It is very important to keep the rails strictly to gauge, and the tie-rods should be fixed as near the top of the rails as possible, because you then get the greatest good from them, and they have greater power to prevent the rails moving; but the paving setts make it very difficult to secure the rods near the top, and we have secured them to the base of the rail. The rails are laid upon a foundation of Portland cement, composed of seven parts of broken stone, sand, and gravel, to one part of Portland cement. The macadam of the roads mixed with cement, in the above proportions, makes very good concrete. The paving is granite, and the setts are placed as nearly as possible level with the surface of the rails. In Rochdale the joints of the setts are filled with pebbles, stones, and coarse gravel, and run in with asphalte, composed of pitch and mineral oil boiled together; but as these tram-lines pass through the districts of a great many local authorities, the mode of construction varies slightly in matters of detail, but substantially it is as you see it upon the drawing, and as I have described it. I am sorry to say the engines and cars are not here at present, or I should have been very glad to have shown you them. We have adopted the Wilkinson type of engine, which has done very good work at Wigan for some time, and has been extensively and thoroughly tested on other tram-roads. The construction of tramway engines has become a speciality, and some of the largest firms in the country are devoting their attention to them. Messrs. Beyer, Peacock, and Co., of Manchester, are constructing a large number of the Wilkinson engines for this line. I will not trouble you with a detailed description of them to-day, but a short notice of them shall be inserted in the 'Proceedings' of the Association for your further information.

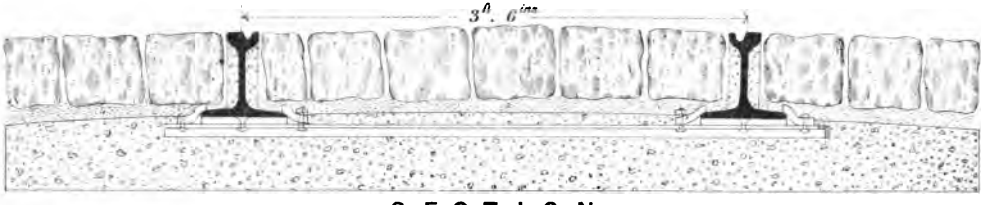
* This rail cost from 9*l.* to 10*l.* a ton, but the cost varies with the market price of steel.

ROCHDALE TRAMWAYS

DETAILS OF CONSTRUCTION

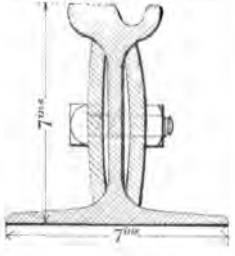


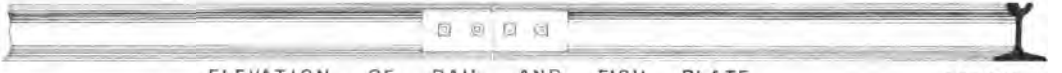
PLAN



SECTION

SECTION OF RAIL AND FISH PLATES.





ELEVATION OF RAIL AND FISH PLATE

R. YANSER, C.E. MANCHESTER.

Rob.t J. Cook & Hammond, Lith. Broadway, Westminster, S.W.

DISCUSSION.

Mr. Fowler: There is no doubt this (Gowan's) rail is a great advance upon other tram systems, inasmuch as it is stronger, and perhaps provides a better foundation for the setts abutting upon the rail. But it occurred to me while listening to your remarks, that paying from 9*l.* to 10*l.* a ton for the rails must necessitate a very large rental, or, I will say, increase the rental considerably more than an ordinary rolled rail. An ordinary rolled rail, without the difficulties and contingencies you have described, would cost 6*l.* 10*s.* at the present market price. Compared with that, 9*l.* to 10*l.* a ton for rails was a very large sum indeed. Tramway directors will look at the expense, and perhaps the local authorities will not get the same amount of interest for the capital they have expended as they would if they had had a rolled rail, as against this expensive rail. Of course if you introduce steam you must have something very substantial, and on a good foundation. But there are other systems which I have seen, which commend themselves to my mind quite as much as this, and they can be carried out at a much less cost. It amounts to this, the cost of the tramways, having regard to efficiency of course, is the thing municipal bodies will look to, and by that they will calculate the probability of gaining a good interest for the money they have expended. In Salford, for instance, they are using an iron rail. If I had to do the work again I would make them of steel, but not of an expensive pattern. Salford obtained ten per cent. on the cost of construction. Now, I think, we can all imagine that, if in Salford there had been an expensive rail like this, the Corporation would not have obtained ten per cent. on the cost of construction. That ten per cent. is a very important source of income to the Corporation. One would look forward to see what amount of percentage the authorities who had undertaken this work would get—five, six, or seven. I question whether they will get ten. There is the traffic to look to, and the thickly populated district through which they pass, but I think it is well to bear in mind the percentage you will get upon the money laid down in an undertaking of this sort.

Mr. McCallum: When with this section of rail (Gowan's) the wearing part is worn away, you have the whole of a girder of the expensive section spoken of by Mr. Fowler also spoiled or

comparatively useless. Instead of this, is it not better to have a thing that you could easily renew, in the shape of a movable steel rail with an equal bearing and efficient attachment to a permanent longitudinal sleeper?

Mr. HEWSON: I should just like to point out, that the first cost of these works is not, I think, the true basis of comparison as to their cheapness. In judging whether a steel rail is or is not too expensive, compared with an ordinary wrought rail, you must have regard to the probable annual expenditure upon the two systems.

Mr. PLATT: There is one point, I do not know whether it is in the knowledge of the Members present that the North Staffordshire trams, which I believe are laid on the Vignoles system, have been found unequal to steam traction. At a meeting of the shareholders not long since there was a considerable amount of discussion and complaint that the lines had not been laid in such a way as to be suitable for steam traction. That is the great point to be borne in mind, especially in a system like this. You must get a good strong rail and a good foundation. It is a question of annual expense, after the first cost, especially as the Company has to keep the rails in order.

Mr. SPENCER: You, Sir, appear to be anxious to pass on to the next paper, which is a purely sanitary matter. But it must not be forgotten that besides being a society of sanitary engineers, we are a society of municipal engineers, and the question of trams is one which, if it does not affect every one present, certainly will affect the engineer of every local board throughout the country in time to come. Therefore it is to us a question equally important with sanitary matters. I have no wish to detain the meeting on this subject unnecessarily, but it is such an important one that at the risk of curtailing a little of the discussion on sanitary matters, which come up at every meeting we hold, I think a little discussion on this point will be useful with regard to the construction of trams. I observe that in this case you do use tie-rods. Now Mr. Gowan, whose rail, I hear, you are using, has lately been constructing trams without any tie-rods whatever; that is to say, he simply lays a rail on a strip of concrete without tie-rods at all. That is found to be equal to every requirement that arises. The weight of the rails, 93 lb. a yard, is a most important element. The continuous-girder system of rails is one which will be found to be absolutely necessary in my humble opinion (hear, hear). For any tram which may hereafter be constructed for steam power, any system of upper rails,

which may be taken off the bearing underneath, and any system on which steam is to be used that is dependent upon screws and bolts, when steam power becomes universal, as it is certain to, will be found to be inadequate. And so far as I can judge, the only system of rails which will be equal to the emergencies required of them is the continuous-girder system, everything of uniform and equal bearing through the whole system (hear, hear). Another very important question arises regarding the trams of the future. I say future advisedly, as distinguished from what I may call the detached system of the trams of the past. That is the gauge. I think it is most unfortunate that a difference has arisen in the gauge of the particular trams that you have described. When trams were first commenced in this country it was thought earnestly that they were only necessary and would only be required, in the large cities and towns. If that were the case the gauge was practically an unimportant matter, because every town might adopt its own gauge, whatever that might be, at its discretion. But recent events have shown us that the development of trams is more to link all our towns and districts together, than merely to go through the crowded streets of any large city. That being so, it naturally tends towards uniformity of gauge. Now the 3 feet 6 inch gauge, I believe, is equal to every requirement so far as safety is concerned. But we have the 4 feet 8½ inch gauge already adopted in most of the large towns and cities,—with the exception of the district of Birmingham, which has a great many lines under the 3 feet 6 inch gauge, practically every city throughout the country. Out of the 70 or 80 trams which at present exist, only about 20 have, I think, narrow gauge; the remainder have the 4 feet 8½ inch gauge. The mileage, however, gives even a larger proportion than this. The mileage of 4 feet 8½ inch tramways in the United Kingdom, speaking in round numbers, is something like 600 miles. The mileage of trams at a less gauge is about 220 miles. Then take again the applications to the Board of Trade and to Parliament during the present session. You will find, out of between 50 and 60 applications, that 32 are on the 4 feet 8½ inch gauge, and about 20 on a less gauge. But when you come to look further into it you will find that the proportion of mileage applications for the present session is about the same as the existing tramways throughout the country in the ratio of 5½ to 2. You will then see that events at present point in favour of the 4 feet 8½ inch gauge, and therefore this question of gauge is one which is

of the greatest importance to us as representatives of the various municipal authorities throughout the country. I think that a great inconvenience will be found from the indiscriminate introduction of fancy gauges, suited to the ideas of the individual engineer who happens to project the tramway. The mere question of cost is not sufficient advantage to the companies to warrant them in disjointing and disorganising the whole tramway system in the county or district. You have perhaps a saving of 200*l.* or 300*l.* a mile in the paving by adopting the narrow gauge, but I believe it will be found in the future that the uniform gauge will be 4 feet 8½ inches. Of course we are bound to that gauge in consequence of its having been already adopted in so many large towns, and, as I say, in the proportion of 5½ to 2 in the mileage. Therefore 4 feet 8½ inches naturally tends to be the gauge which must be adopted throughout the country. I would just remark, before I sit down, on the question of motive power. The Wilkinson engine I believe to be a very good one, and on the trams on which I am at present engaged as engineer I have them now in progress, and hope to have them at work within the next two months. But I may just mention, as a guide to any engineer who has this question before his authority, that there is a very good type of engine now working at Dusseldorf. In this engine there is no fire in the motor, and it runs with a total absence of smoke and fumes. The cost of coal is to some extent saved. Of course coal has to be used in generating the steam at the central boiler, but at the trial—or rather I should not say trial, because it is running in the town of Dusseldorf in the ordinary way, on the tramways there—when I saw it the engine was charged with sufficient steam to carry it the whole journey of 7 miles out and 7 miles back. That is a journey of 14 miles. Now, if you can charge an engine with steam or superheated water sufficient to carry it for 14 miles, that is practically all that can possibly be required. I do not myself give any very strong opinion, because any gentleman here, who has an important tramway on hand, either as representing a company or as representing his own authority, can go to Dusseldorf and see it. There it is running regularly. The steam being taken from the stationary boiler, there is no smoke, and no fume from the water. I would recommend every Member of the Association to give his attention to that class of motor, which is one which is very likely to do away with many objections on the part of the town authorities.

Mr. McKie: I should like to say a word or two about the gauge, rather in favour of the 4 feet 8½ inch gauge. That is the ordinary gauge of railways, and as that gauge of rail was adopted previously from the gauge of the old coaches, it naturally fits into the ordinary vehicles that run along ordinary roads more than any other gauge. The consequence of that is that when a tram is constructed 4 feet 8½ inches in width, ordinary vehicles, when the car is not on the line, take to the line without doing it any damage and without doing the road any damage. If the gauge is less the majority of vehicles might take the tram-lines on the near side rail, and one wheel would be on the line while the other would be making a groove in the macadam. Of course, in a road which is paved right across from channel to channel, it does not make much difference, but where the tramways are laid in a macadam road it is a very serious cost to the ratepayers. Where a 4 feet 8½ inch line is used there is no bother. The vehicles take the two lines, and there are very little repairs on the road. That does not make much difference to a company, where the lines belong to a company, but when the road and the lines belong to a corporation, then the repairs are very heavy. With regard to the cost of the rail, that struck me when I first saw it as being a very expensive item. No doubt the first cost of the tramway is a very serious consideration, and if that cost can be reduced by a small alteration in the pattern of the rail—simply a reduction in the cost of rolling—I think that ought certainly to be considered very carefully before deciding on the design of the rail. The mere alteration of the pattern would reduce the cost down from over 9*l.* to something like 6*l.*, and it is certainly a question whether that could not be saved. I would just point out that the weight of the rail, 93 lb., is much heavier than even the heaviest rail used on railways. The majority of the main line of railways are about 80 lb. a yard, steel rails carrying engines 40 and 50 tons, and it seems to me rather an excessive weight for the rail of a tram, which is only for carrying light passenger traffic, to be 93 lb. On the other hand the wide flange of the rail, if imbedded in the concrete, would require no other fastening but fish-plates to make a good firm tramway, and would reduce the number of articles and the labour in laying the rails to the minimum.

Mr. Escott: In walking down from the Rochdale station this morning I noticed that the road was rather steep, and I believe that when the line gets to the bottom of Drake Street it leaves the

main street and goes along on the low level. Is that on account of the street opposite being too narrow, or on account of the gradient?

Mr. PLATT: The gradient of Drake Street is 1 in 16.

Mr. SPINKS: Have you tried the system of the Surveyor of Manchester, putting asphalte under the rail? The Manchester trams, everybody knows, are on a continuous sleeper, and when you ride inside them they are very noisy. There had been a suggestion that the City Surveyor should put down the lines on this pattern—a 14-inch base of concrete, instead of continuously across the road, and pull up the setts in between the rails.

Mr. VAWSER: As engineer for this line I am glad to find it excites sufficient interest to cause a little discussion. We usually devote our time at these meetings to sanitary matters, and I thought really to make this subject subordinate to the sanitary work, and only mentioned it incidentally to create a little additional interest. But if I had been aware that the Members would take so much interest in it, I would have given a much fuller description of it at the commencement. With reference to the questions that have been asked, you all know that the first cost of a tramway is a small matter compared with the future working cost and maintenance of it, and in this instance it has been thought advisable to consider the ultimate cost of repairs rather than the first cost. In constructing this work therefore, the most substantial form of rail has been adopted. I think I said before that the Barrow Steel and Iron Company is the only establishment that has laid itself out to roll this class of tramway rails, and although it has cost the Tramway Company a very great deal more money to put in this class of rail, they have preferred to do so rather than be saddled with additional cost for repairs hereafter. In dealing with steam traction we knew that whatever else was done we must have a continuous bearing for the rails, and consequently many types of tramway rails that have been adopted elsewhere were unsuitable for us. We were therefore somewhat limited in our choice from the first, but when we came to investigate the matter closely, and look to the various advantages claimed for each type of rail, we found the advantages the Gowan rail offered fully counterbalanced the additional cost it involved, because with steel at its present price, it costs only a small sum per mile more than other types of rail; that is to say, the Gowan rail constructed entirely of steel, as you see it on the drawing, costs at the present time very little

more per mile than a light-steel rail on a cast-iron chair, which would not last one-half as long under steam traction. It will not be overlooked that with the Gowan rail we require no separate sleeper of wood or iron, as the concrete is brought to a smooth surface and the rail laid direct upon it. A Member has suggested that if cast-iron sleepers had been used, a worn steel rail could be taken out, and a new one put in, and the road paving remain undisturbed, but none of us know the duration of a well-laid tram-line: with ordinary wear and tear I think it might last from twenty to forty years, and I think if the tram-rails wear even for twenty years, the street paving will likewise want renewing at the end of that time, and the tramway and road paving should all come up and be renewed together. Many systems of tramway construction have come to grief in consequence of faulty construction and defective fastenings, and the great difficulty of finding an efficient mode of fastening the steel rail to the sleeper presents an insuperable obstacle to the adoption of a compound system for steam traction. I think it was Mr. Spencer who mentioned the tie-rods; I agree with him in a great measure, and in a town where the roads are paved from side to side, I do not think a tie-rod is of any consequence whatever, and I am not quite sure that it is in any case. But at present there is not much experience to guide us to the effect of steam traction on tram-rails, and we want our system to withstand a very heavy traffic with steam traction, and as a tie-rod can at any rate do no harm, we have thought it best to use one, and we have put it in as additional security: we hope it will enable the road to last a little longer, and it seems the best thing we can do in a system that is comparatively untried. With regard to the gauge, it is very much to be deplored that we have not uniformity of gauge in tramways, because if we had, the engines and other rolling stock would be constructed at a very much cheaper rate. But there are various reasons why those who are promoting tramways at the present time cannot always adopt the same gauge. The 4 feet 8½ inch gauge in tramways was originally adopted with the idea that railway trucks could run upon tramway lines, but that probably has ceased to have any force now, and tramways are constructed as tramways pure and simple. The Corporation of Birmingham are now contemplating altering their 4 feet 8½ inch gauge to 3 feet 6 inches so as to correspond with the gauge of other tramways now in course of construction in that neighbourhood, and I should not be surprised

to find in the course of time that other owners of tramways will change the gauge, but whether 3 feet 6 inches, or 4 feet or 4 feet 8½ inches will be the gauge of the future I don't pretend to say. Last year the gauge of a tramway I was connected with was altered in the Committee of the House of Commons from 4 feet 8½ inches to 4 feet in order to fit in with a neighbouring tramway, and I am told General Hutchinson rather advocates a 3 feet 6 inch gauge; we had special local reasons however in Rochdale and Bury for adopting the 3 feet 6 inch gauge. The system of working tramways with a continuous wire rope has not yet been tested in this country, and we have had no experience of it at present, and I look forward with very great interest to the experience we shall gain when that system is brought into practical use.

In answer to another question, I have to say that the concrete foundation or bed extends over the whole statutory width of the tramway, including 18 inches outside the outer rails. We think it is a better support to the paving, which we desire to maintain by the best means we can, and so reduce the expenses afterwards. If we had thoroughly well-paved roads such as in Manchester, we might have cut out a space of 2 feet wide in the paving in which to lay the tram-rails; but as the paving had to be entirely reconstructed, we thought it better to take up the whole width of the tramway at once, and put down a continuous width of concrete. I can give no information about asphalte under the rails, it is not so used here. Mr. Spencer has produced a surprise, as he generally does at our meetings, in telling us about the fireless engine that is working in Germany: I shall hope to avail myself of some early opportunity of seeing it, and shall make further inquiries about it: if it continues to work satisfactorily and economically, I shall be very glad to see it extensively used in England.

THE VENTILATION OF SEWERS AND HOUSE-DRAINS.

By R. READ, Assoc. M. Inst. C.E., City Surveyor, Gloucester.

The water-carriage system of sewerage may be said to have been fairly inaugurated by the Public Health Act of 1848, and although epidemics were of frequent occurrence during the ten or twelve years immediately following, the majority of scientific men took but a very feeble interest in the unsavoury subject of sanitary science until the death of the Prince Consort in 1861; this set everyone to work to discover a remedy for fever epidemics, which doctors and chemists plainly stated were probably caused, and certainly spread, by defective sanitary arrangements.

A perfect shoal of patent traps and closets were brought out, all warranted to keep back the much-dreaded sewer-gas, but notwithstanding these, and the timid trial of ventilation, with many precautions in the shape of charcoal-trays and other obstructions, the public were again startled by the illness of the Prince of Wales in 1871. A fresh crop of patent apparatus followed, to the great bewilderment of those whose faith in the magic word "patent" caused them to take the statements of inventors or patentees without the necessary grain of salt. Ventilation in the meantime progressed quietly and steadily, until it has now become the recognised practice to place ventilators from 50 to 100 yards apart upon all new sewers.

In a period of forty years the sewers of a town pass through many stages of alteration and development, and it frequently happens that existing sewers are partially retained and become portions of a new system. This may be all right if the old sewers are in good condition, and are laid in the public streets, where they can be examined, flushed, and ventilated by the sanitary authority, but when they are at the backs of houses, crossing private gardens belonging to many owners, and are not ventilated, they become a serious cause of evil.

The accompanying diagram shows an arrangement of this kind

as it was unfortunately carried out in Gloucester in 1875, after the extension of the city boundaries to take in several outlying parishes, whose sewers discharged into an open brook. It will be easily understood that the ventilation of the new sewers in the public streets at every 60 yards caused a very great nuisance to arise, the long pent-up gas from the old sewers finding free exit from the vents in the new ones as soon as the two were connected.

To allay the fears of the public, charcoal pans were placed in the ventilators, contrary to the advice of the engineer; the nuisance in the streets was thus abated, but as the pans were practically nothing but stoppers, the real sanitary condition of the town was rather worse than before. The writer was called upon soon after his appointment in 1878 to report upon this state of things, and being then ignorant of the existence of a dual system, recommended free flushing, to be followed by more ventilation; accordingly during the winter the charcoal pans were removed, and 100 manholes in the old part of the city ventilated, but a return of warm weather brought with it a recurrence of the nuisance, which no amount of flushing in the new sewers could abate: a thorough investigation revealed the fact that the old sewers were all "picked up" by the new wherever they crossed each other, and the mystery was at once explained. No doubt this was intended as a temporary measure, to give the owners of property time to transfer their house-drains from the old sewers at the back to the new in the front, but with the result that there are still 1200 houses connected with the old sewers, thus preventing the latter from being closed.

This point has been dwelt upon somewhat fully, because it is quite possible that something of the kind is of not unfrequent occurrence. A consulting engineer designs a system of sewers for a provincial town, which of necessity must have some existing system, however bad it may be; a contractor from a distance carries out the work, but the local authorities, to keep down the rates, or for some other reason, leave the transfer of the house-drains from the old system to the new to be carried out by the owners of property at their leisure or discretion, which means that unless the house-drains stop altogether nothing is done; for the majority of owners of house property neither know nor care where the drains go to as long as the water runs off and they can get their rents.

Sewer-gas is almost universally dreaded as a highly deleterious compound, but our knowledge of its actual composition and action is by no means extensive nor final. The following table shows

the names and specific gravities, compared with hydrogen and atmospheric air, of a number of gases given by several eminent authorities as component parts of sewer-gas:—

Gas.	Specific Gravity.
Hydrogen	1·00
Atmospheric air	14·25
Sulphuretted hydrogen	17·00
Carburetted „	8·00
Olefiant gas	13·00
Ammonia	8·50
Carbonic acid	22·00
Nitrogen	13·85
Sulphurous acid	32·00
Bisulphide of carbon	38·00
Chlorine	35·50
Watery vapour	9·00

The whole of these are not always present, but the heavier gases as a rule predominate, such as sulphuretted hydrogen, nitrogen, and carbonic acid; the question therefore suggests itself, Why does sewer-gas rise from the sewers, notwithstanding its components are heavier than the air? This is caused—1st, by pressure upon, or displacement of the gas by reason of an increased flow of sewage; 2ndly, by diffusion and natural expansion of the gas itself; and 3rdly, and most commonly, by being absorbed or entangled by the light watery vapour constantly arising from the sewage, which acts as a vehicle to carry it out of the sewers. The first is merely mechanical displacement, but the second and third methods are caused by variations of pressure and temperature of the outer air as compared with that of the sewage.

The temperature of sewage in the sewers varies from 40° Fahr. in winter to about 60° in summer, that of the atmosphere at the ground level from several degrees below freezing-point in winter to 80° in the shade in summer; but the temperature of sewage will not vary more than 3° in the 12 hours of a summer day, while that of the atmosphere will vary 6°, 10°, or even 20° in the same time, and during summer is always warmer than the sewage. These differences of temperature are accompanied by constant variations of atmospheric pressure causing the gases to expand, and watery vapour to arise from the sewage; this vapour being lighter than the air carries the gas out at the street ventilators. This action is particularly apparent during a spell of dry weather, when the sewage is in its most concentrated form and evaporation is most active. The action is intensified when a sudden fall of the barometer indicates the near approach of a storm; the

expansion of the gas is then sufficient to carry it out of the ventilators without the aid of the watery vapour as a vehicle, and therefore it is discharged under our noses in its most offensive and undiluted form. But even when mixed with watery vapour the latter expands so rapidly upon reaching the outer air that the heavier gas is left to fall to the ground if there is not sufficient wind to disperse both before the separation takes place.

In winter, when decomposition is at its minimum, and consequently little or no gas is generated, the watery vapour predominates, and if the outer air is colder than the sewage the vapour is sufficiently condensed to become visible, rising like smoke from the ventilators on a frosty morning: it is then, however, quite harmless, from the absence of decomposition.

The above is the action of a system of sewers having the outfall below low-water mark, and ventilated as at Gloucester by open grids 36 square inches in area at every 60 yards along the public streets; this is so because the difference of level between two ventilators at that distance apart is not sufficient to convert the lower one into a downcast shaft and the upper one into an upcast shaft, but the action is simply a slow respiratory one, due to the expansion and contraction of gases and watery vapour, overflowing or not from the ventilators in response to the atmospheric changes above mentioned. But no system of ventilation can be efficient that does not establish a constant current of air through the sewers and house-drains of sufficient strength to prevent a reversal of direction under all ordinary variations of the atmosphere; nevertheless we do not want to produce, or even stimulate, a general tendency or rush of gas to the higher branches of a system of sewers, or to any one point in a town, but on the contrary, the object of ventilation is, or should be, to prevent the accumulation of gas by passing a free current of air through both the sewers and house-drains.

To prevent this accumulation of gas, ventilation alone must not be relied upon if the sewers are in any way defective, or a nuisance will be the result; and although it is better to have the gas discharged into the open air than into private houses, it is difficult to convince the general public of the utility of any system of ventilation that emits a stink into the streets; for defective sewers there is an obvious remedy, therefore ventilation to be successful should be applied to well-constructed sewers with gradients sufficient to keep them free from deposit.

In such a system of sewers, the sewage passes off before decomposition sets in, and it is only the vapour from fresh sewage we have to deal with by ventilation; this vapour should not be discharged in its crude state at the street grids, but the latter should be converted into inlets for air, the outlets for the oxidized vapour being above the roofs of the houses, some 30 feet or more above the street level.

In order to establish this current of air entering downwards at every street grid, it is necessary that the ventilating shafts fixed against gable ends or other convenient walls of the house, should be so numerous, that the sum of their sectional areas should exceed that of the two street vents between which they are placed, sufficiently to overcome the friction of the air through the pipes; these should be not less than 4 inches in diameter, and may be either independent connections with the sewer, or simply the continuation of the house-drains.

In a distance of 60 yards we may have, say twelve houses in close order on each side of the street, or we may have say eight semi-detached houses on each side in the same distance, so that at the lowest estimate we shall have sixteen soil-pipes 4 inches diameter, or about 12½ square inches sectional area each, that can be converted into ventilation outlets, or a total of 200 square inches of outlets sucking away at 72 square inches of inlets.

But the property owner asks at once, Why should I help to ventilate the public sewers? The answer to this is, that the sewers are laid down for the benefit of the houses draining into them, and therefore those who use the sewers should also help to ventilate them and thus complete their efficiency, by simply ventilating their own house-drains; that is to say, the sewers and house-drains should be treated as parts of the same system, as mutually dependent upon each other as a man's hand and fingers. In detached or semi-detached houses, where the drains can be kept outside, there is no reason why the soil-pipes should not be continued 4 inches diameter up above the roof as a ventilator, but with houses in close rank there may be some risk, although there should not necessarily be a great deal, if the sewers and house-drains are properly constructed; in passing the drains under the houses, in this case, therefore, it is safer to ventilate the house-drains independently, and have special ventilators for the sewer in addition, although such a proceeding doubles the expense.

If these conditions could be obtained, and there ought to be very

little difficulty about it, there would be no necessity for any complicated closet apparatus from 50*s.* to 100*s.* prime cost; but a simple pan and siphon trap, such as the "Artizan," now made by several makers, is all that is necessary, provided always that they have a good flushing rim discharging the water from all sides straight into the siphon. The flushing-box should never be less than 6 feet above the seat and have not less than 1¼ inch flush-pipe.

In conclusion, notwithstanding the almost universal condemnation of the pan and container closet, about which Mr. Pridgen Teale quotes from 'Scribner's Magazine' of New York that "it probably is not, but it certainly might be, the invention of the devil," they are still to be found in the majority of indoor closets and are even now fixed daily by builders and plumbers who must or ought to know their defects.

DISCUSSION.

Mr. Fowler: We have had several papers on the ventilation of sewers from time to time, and it is not well to make comparisons I know, but I do not think that for scientific treatment of the question, we have had a paper dealing so carefully and so ably, perhaps, as the present one. The other papers have generally dealt with the passing off the sewage by means of channels, conduits, or something of that class; but this one goes deeply into the scientific researches of the question, and I think we ought to be deeply indebted to Mr. Read for the very able manner in which he has brought it forward. In regard to the connection of sewage with the wells in towns, I can bear testimony to that serious fact, inasmuch as at Cardiff, some twenty-seven years ago, when I was there, the wells of the town were formed in gravel. All the town of Cardiff is gravel formation. The sewers, I may say, were along the centres of the streets, and cesspools in many of the gardens, and a plague prevailed throughout the district—small-pox. The surveyor at that time, Mr. Wareing, who held the appointment just previous to my engagement with him, was fearfully disfigured—I apprehend in the discharge of his duty—with the malady, and it was traced, principally, I believe, to the connection of the wells with the sewers. It is easily understood that the sewage or liquid filth percolates through the gravel into the wells. The wells being a little deeper, perhaps, than the sewers, had the effect of drawing it from

the sewers into the wells. I do not mean to deviate or to turn from the question of the ventilation of sewers, but I would remark that in 1832 a similar thing occurred in London. Then, by a public enactment, the whole of the privies were swept away from the metropolis, and water closets were introduced. We know that London has now a less death-rate; a steady rate of about 20 per 1000 throughout the year. That supported what Mr. Read had said. Whilst practising on the ventilation of sewers in Leeds, with my colleague (Dr. Robinson), we proved this to be the case beyond doubt. Therefore it is with pleasure that I support Mr. Read's views.

Mr. HEWSON: I am sorry, Sir, to rise, to say that I do not feel that the author has presented us with a true description of the action of sewers as they really operate in towns. Of course I would much rather have added an opinion of approval than what I am going to say. However, we are here, as I take it, as a mutual improvement society as much as in any other capacity. I would like to put my remarks in the form of a question. The author claims to ventilate sewers by a motive power, which he gains by the difference in the height between two inlets of a sewer; that is, the difference in height between the grid in a street, and the top of pipe, say if you like 30 feet higher. He claims that if such an arrangement were made, circulation, so to say, would take place; exhaust the foul air and substitute purer air from the street. The difference in these two levels is what is going to do this. Now, how can that be, when perhaps 200 yards higher up the same street, the grids there might be 50 feet higher than the first grid? How can you expect that this isolated, and local, and special circulation will take place against the general set or current of gases in the sewer making their way to the higher levels of the town? In my opinion, what would take place if such a system as that suggested by the author was carried out, would simply be this—all low inlets in the lower parts of the town would supply air for the general circulation taking place, and it would be again discharged at the higher levels of the town. From my experience I have come to the conclusion that you cannot get this local circulation.

Mr. GODFREY: This is the first time I have had the pleasure of attending a meeting of the Association. I am glad to hear the remarks on the ventilation of sewers. My attention has been directed to the subject for some time past, as I have been connected

with one town in which the plan recommended is very fully carried out. I refer to the town of Kendal. They have a large system of sewers there, and the Corporation has done very much to induce owners to ventilate every branch drain. They have also erected a great many 6-inch ventilators where they could get permission. The physical geography of Kendal is such that the old portion of the town lies in a valley, and the new portion is upon a hill, varying in height from 50 feet to 200 feet, and there is very little cause for complaint from the sewers in the town. In the district I represent now there is only one upright or shaft ventilator. That was put up just before I took charge of the district, because there was a fearful stench from the manhole. From my investigations in this district, as well as in Kendal, I have found that very frequently the stench from a manhole is caused by some local circumstance (hear, hear), and that it does not follow, because one manhole stinks, that you must condemn the whole system. If there is that preponderance of sewer gas, as so many of the opponents of the sewerage system of the country are so fond of asserting, when one manhole smells the whole of them should smell, if the thing was to be consistent. I have had one or two striking instances lately of the reasons why one or two manholes have smelt, and it puzzled me very severely for eight months to discover the cause. One was in such a state that several tenants in the district gave notice that they would remove unless a remedy was effected. The Corporation of Birmingham, who supply the gas, were charged with being the cause of it, and took up the whole of the gas main for 300 yards, and it was found that the gas leaked into the sewer. That was often the cause of far more nuisance than all the good flowing sewage put together. If sewage was allowed to become stagnant, and accumulate—and I am sorry to say that in some instances there are five or six inches of fæcal matter in the sewer—you will have a stink, and I do not think upright shaft ventilators, or any others, will do away with it. The only thing is to keep the stuff clean out of the place. With regard to the ventilation of private drains, under the model bye-laws of the Local Government Board, the owner of every new house is called upon to ventilate his own drains. I think we should each, in our own districts, put it strongly to every owner of property to contribute towards the ventilation of his portion of the sewers. Until we have our general system of sewers perfectly ventilated by increasing the number of inlets very largely, we shall never be free from these

false charges that I am sorry to say are now so often laid against the sewers. I have been very much gratified with Mr. Read's paper.

Mr. McKie: About the open ventilation. If I understand Mr. Read's paper aright, he is for a free and open ventilation. Does he mean to have any disconnection of the house drains from the sewer, or that each house should assist in ventilating the public sewers? Of the gases in the sewers, some are of a heavy, and others of a light specific gravity. Still there is this about the diffusion of gases: Carbonic acid gas is 22 times heavier than hydrogen gas. If you put carbonic acid gas in a bottle it goes to the bottom, and hydrogen gas at the top. You will find that they will change places; which shows that there are other means and other laws for the diffusion of gases in addition to the specific weight of the gases. Then, whether Mr. Read is right or not in saying that all the heavier gases remain on the surface of the street, may be a matter for those who are better acquainted with chemistry than I am, to determine. I quite agree with Mr. Read in saying there should be no trap between private drains and the sewers if both are well ventilated, and that each house should contribute to the ventilation of the sewers. Traps are abominations (hear, hear). If you make a trap you simply stop the circulation. A trap, when not ventilated on each side, is, in my estimation, wrong. Every yard of sewer that you do not ventilate thoroughly you make into a nest for breeding disease. I am well aware, when I say this, I shall have people to say at once, "You must disconnect the house drains; the fever will go up the pipe if you do not." My good sirs, if you have gas jets in your house, and if you turn the taps on without lighting the jets you will be all poisoned. If you want to ventilate your sewers, and you ventilate them so badly that the gases from the main sewers enter your dwelling, you will be equally poisoned, through no fault of the system, but by bad workmanship. You might as well say, "We won't burn gas, because, if it escapes it will poison us, or blow us up. We won't have water, because, if the pipes are defective, they will drown us, or make our house damp." Have your drains and ventilation as perfect as your water and gas pipes, and you will not suffer from them. At Frankfort, where there is no disconnection between the main sewers and the house drains—where it is free and open—there is generally speaking a down draught at the manholes, and upcast to the top of the houses. These sewers are the best I know of, and were constructed by Mr.

Joseph Gordon. Let there not be a yard of sewer unventilated. Let air move up or down, let it keep going, and then we shall have a system of sewers you need not be afraid of.

Mr. Cockrill said: The model bye-laws will compel every householder to disconnect private drains from the main sewer, and to provide his own ventilating pipe. We are about to adopt the model bye-laws. The Council I represent decided, on Tuesday last, on a report of mine, to spend the sum of 8000*l.* in inserting ventilating grids in every 50 yards of sewer. In addition to that I divide the sewers into lengths of 400 yards, by means of light galvanised iron doors. I recommended the use of a 3000-gallon flushing tank which will be put over the sewer, and supplied with water from the mains. We have a number of chimney shafts erected on the highest points of the sewers—ten or a dozen, costing from 70*l.* to 80*l.* each—but they have been found of little use. The sewer ventilators that were constructed into the surface, stunk as bad as ever within 50 yards of them, but the sewers were bad. Undoubtedly, in places where they had been cleared out, there was a little abatement of the nuisance. Now we are going in for cleaning them thoroughly well out, and I hope in the result it will do the town good. The gradients of our main sewers are 1 in 300.

Mr. Hewson: A word of explanation, please. I am afraid there will be some misunderstanding. I wish my friends to understand that I of course consider that you cannot have too much ventilation. All that I wished to disagree with in the paper was the theory that I gathered the author wished to set up, viz. that of local circulation of ventilation. That is what I wanted to object to, for I think he would get simply the inlet of cold air. That is what I wish to say.

Mr. Vawser: I am not going to detain the Members very long, except to say, that on a small scale where I have adopted the same thing, my experience has been very much the same as Mr. Hewson's. You may construct up-cast shafts, and what you think will be down-cast shafts, but unless you altogether separate the high level of the town from the low level by means of these air valves, you cannot get the nauseated air to go where you want it, and it has a nasty knack sometimes of going where you do not want it.

Mr. Fowler: My observation of sewers in several large towns is that there is no law for the flow of gases in any particular direction. Dr. Robinson and myself took tests in those towns.

Mr. I. M. Jones: Before Mr. Read replies I should like to ask whether he has made any experiments at all to justify the conclusion at which he arrives, that the sucking away of certain air will produce efficient ventilation? I should like to know whether any real experiments have been made, so that we might not go away with simple assertion. I remember at some former meetings we have had scientific papers, the authors of which had practised and experimented, and have given us the result of their experiments. With reference to Mr. Read and the non-success in flushing, it seems to me he pins his faith upon the sucking away, and the absence of foul air. Of course that is without any reference to our friend who sits at the table—Mr. Fowler. I thought that some one would have made a joke on the similarity of names (a laugh). Flushing seems to me, in combination with open ventilation, to be as successful in my town as it is possible to be. I quite agree with our friend from Kendal, that there are certain manholes that stink; but I have always found that there have been local causes for it. I have no need to repeat what those local causes are, the Members know them as well as myself: dropping down from the high level to the low level, and so causing the stirring up of nasty matter, or else escape of gas from the main, or some other local cause. If I have done wrong in advising my authority to go in for a tank, and to flush periodically with water, I should like to be put right. If the system of sucking away would save us the expense of paying the Water Company 50*l.* or 60*l.* for water, I shall be glad to take home with me something profitable to the body paying my salary.

Mr. McKie: Let us have in the sewers a continual ventilation up or down. This must be done. The sewers ought by flushing to be kept clean. Then you will have no sewer gas to contend with. You simply have the air going up or down, and it will not smell or stink, or cause a nuisance to any one.

Mr. Escott: There is a question asked in the paper, Why should I help to ventilate public sewers? There is no doubt that properly ventilated private sewers would help to ventilate the public sewers. I ask whether you have power to charge the private owner for the ventilation. I am not aware of any such power just at present.

Mr. McKie: If you put it that way, the soil pipe becomes a good ventilator if you carry it up full bore, above the ridge of the roof.

Mr. Read: Mr. Chairman and Gentlemen. I must thank

Mr. Fowler for the kind remarks he has made. I quite agree with him that many of the epidemics are caused by pollution of well water, rather than by sewer gas. Mr. Hewson advanced the opinion, that, supposing the system mentioned in the paper were carried out, the sewers in the town would be simply ventilated at the high levels. Also, as I understood him, half the ventilators lengthways of the sewer would become inlets of air, and the other half of the number become outlets. Well, that is not in accordance with my experience at all. My experience is this, that the difference of level between the street ventilators is too small. Supposing the sewer has a fall of 1 in 100, which is a very fair fall, the difference between one ventilator and another is about a foot. That difference of level is not sufficient to convert one ventilator into a down-cast. The general tendency of sewer gas, or of any other kind of gas, is to adopt a line of least resistance, and the line of least resistance is the nearest manhole, or ventilator. It may rise through the gratings to the street level or not, according to circumstances.

Mr. READ then explained the position he took up, by means of a diagram, and proceeded to say: My experience is that the tendency of sewer gas is to get out at the nearest ventilator. There is now no division into up-cast and down-cast shafts in the whole town, unless it is in a town where there is a very great difference of elevation. It must be a very steep town indeed.

Mr. HEWSON: If you admit that principle is involved, you cannot lay aside the question. They have a syphon ventilator in the sewer here.

Mr. FOWLER: I think syphon ventilators in the sewers are the best thing. I have proved that the air is often rushing down one shaft, and in another it is all rushing up.

Mr. READ: The application, I am very sure, is this, that every house should ventilate its own drain. It is not an isolated case of ventilating one house, but ventilating every house in the town; and I think I show in my paper that even if you have semi-detached houses, you get the ventilators in the street converted into inlets. All the ventilators in the streets should be inlets. There will then be a general down current through every ventilator in the street, going out by syphonage through outlets above the houses, 30 feet above the street; if more, all the better. We had several cases of scarlet fever in one street, where the back sewer was picked up by the front sewer. It was rather a worse

case than the one shown there (on the diagram). There was only 6 inches difference in the level between one end of the street and the other. The old sewer and the new sewer ran in opposite directions. The old sewer was brought to the front, and connected with the new one. The stink from this sewer was something abominable, and the scarlet fever was put down to it; but I think there was good evidence to prove that the stinks had nothing to do with the scarlet fever, which was caused by bad water. Every house in which the scarlet fever originated had a supply of well water. After the scarlet fever appeared there was a great outcry against the ventilators in the street. The only thing I could get them to do was to ventilate the sewer, and I ventilated it by putting pipes up the backs of the houses, and in some cases up the fronts of the houses, in such proportions as would oxidise the sewer gas. Then no gas came from the street grids, but all went up through the ventilators at the top of the houses. A gentleman opposite mentioned about ordinary gas leaking into the sewers, and I can support that idea, because I know that gas from the mains very often does get in the sewers in very considerable quantities. I have had it burn up through the ventilators in some cases, where lights have been applied. Mr. Cockerill mentioned the modern bye-laws, and said they insisted on a trap being fixed between them. So they do, and in my opinion it is quite unnecessary. But when I say it is quite unnecessary, I mean this, that the sewers laid down should be of such good condition, so well constructed, and with such good gradients, that they give a velocity of 3 feet per second. If you have that velocity there is very little deposit in your sewers. That velocity is sufficient to carry off all the sewage in Gloucester, if not in an hour, in one and a half hour's time, and in that period no decomposition can possibly take place. It is only where there is decomposition that you have any sewer gas, and in the absence of decomposition, all you have to deal with is watery vapour from the sewage. That will decompose if it is not ventilated, therefore my proposal is simply to carry off that watery vapour, so that it does not accumulate, decompose, and become gas. Experiments were made in the streets, and I made them also at a private house belonging to a medical man of the town. From them I discovered, or came to the conclusion rather, that it was absolutely necessary, in order to get a constant draught, that the outlets should be in excess of the inlets. While that is the case, the draught will be constant. Directly you reverse this, then your

system is not perfect. The figures which I gave as to temperatures, are figures I ascertained myself by experiment on the different sewers during the past year. One gentleman asked me about flushing. I would explain what I meant. My remarks in the paper were these. You can flush the sewers as much as you like, but that does not touch the old sewers, simply because the old sewers are upon private property crossing the back gardens of the houses.

Mr. Escott asked about the power of fixing the ventilating pipes. We have power now, under the model bye-laws, and under most new bye-laws, to compel persons to ventilate their house drains, but we have no power to compel them to fix ventilators from the sewers against their houses. As a matter of fact, I have got, by persuasion, as many as fifty—I think it is—of these shafts erected in various parts of the town, against private houses, with the consent of the owners.

THE MANURE-DRYING APPARATUS IN USE AT BIRMINGHAM.

By A. M. FOWLER, M.I.C.E.

Farmer's system of disposing profitably of town excreta has proved a very great success, but as yet has only been tried by the Birmingham Corporation. The merit of the system lies mainly in the disintegrating or pulverising power of the machine during the whole time it is at work. The pulverisation of the mass under treatment is effected by the interlocking of the scrapers attached to the two interior steam-heated centres, which revolve in twin pans, each having a longitudinal section removed, which pans are bolted together to form one twin cylinder. This twin cylinder is cased for steam heating to heat the wet stuff undergoing evaporation and the vapours are exhausted by a powerful fan, and passed to a condenser, and thence to the sewer, after being disinfected.

Economy is also effected by the Farmer machines through the accuracy with which they are made. The interior surface of the pans is bored out to a true cylindrical form, so that the scrapers cut off everything on this surface, and prevent caking. The necessity of this will be more readily understood when it is stated that excreta is a non-conductor of heat, and if it is not cleaned from the interior surface of the pan it has the effect of insulating the heat of the casing from the bulk of the stuff. The results obtained at Birmingham have exceeded the anticipations of what these pans were constructed to do. There are three machines on other principles at work, viz. 13 feet long and 4 feet 6 inches diameter by one maker, and two 13 feet long by 6 feet 6 inches diameter by another maker, and at the time this report was made one of the "Farmer" machines. The total amount evaporated in one week was 160 tons, out of which the five one-cylinder machines it is said did 49 tons, the remaining 111 tons being treated entirely by the "Farmer" machine. Again, it is also stated that, taking the pulverising power of the machines, the dried manure came from the five pans in lumps, whereas the "Farmer" machine made it into powder, which makes it more valuable for spreading over the land. The Farmer process is a new one, but statistics

of its more recent practical results can be obtained at any time from Mr. Wilkinson, Superintendent of the Birminghan Interception Department, where the machines can be seen at work. The following technical description of the machine may help to give a better insight into its construction and acquaintance with its principle.

It may be said to consist of a fixed steam jacket or casing of a twin cylindrical form, with closed ends in which cylinder jacket or casing are mounted two hollow steam-heated axles, each provided with a series of blades, or beaters, which latter are set, by preference, at varying angles, so arranged and geared together, that when they revolve they pass between each other.

This twin cylinder steam jacket is cast or formed into about eight sections, bolted together by means of external flanges, and capable of resisting a steam pressure of 70 lb. per square inch. Each cylinder has about one-third its circumference removed, the two open sides are placed together, and united by flanges and bolts, so that when the blades or beaters revolve upon their axis, inside the two cylinders, the said blades will interlock and break up and disintegrate the semi-dry material and prevent it forming into lumps (whereby the moisture is trapped) as it sometimes does in machines of one cylinder.

The ends of the blades or beaters are provided with scrapers which are so pitched around the axes, that are of such a width that no two scrapers scrape the same surface, but that all the scrapers in conjunction work in one revolution of each of the said axes, and entirely scrape or clean the inside surface of the steam-heated casing. This casing or twin cylinder steam jacket is made of cast iron in longitudinal parts or segments to be convenient for transport or erection. The joints are planed to the necessary angles and the segments are bolted together by external flanges, after which they are bored out to make a true cylindrical internal surface, enabling the scrapers to be set close to the said surface to prevent any coating of non-conducting material from caking thereon to retard evaporation.

Thus the heat is greatly economised and the evaporation greatly accelerated. The hollow sections are connected by branch steam-pipes attached to the main steam-pipe, and the condensed water is removed by similar pipe connections.

The hollow axes are geared together by a pair of equal-sized spur wheels, so that they revolve in opposite directions; one of these spur

wheels being driven by a spur pinion, keyed on a shaft, which is actuated by a steam engine (preferably of the double-cylinder diagonal class) or by other suitable power.

The vapours produced by the drying of the excrement or other matter are drawn off at the top of the machine by a fan or other exhauster, and are sent to a condensing apparatus.

The "wet stuff" to be dried is poured in through openings at the top, and the manure powder is discharged through balanced doors at the bottom.

VISITS.—1. Gas Works.

By the kindness of Mr. F. B. Ball, gas manager, the Members were shown the plant recently erected at the gas-works for the treatment of the residual products. That part of it which is devoted to the treatment of the tar consists of two 10-ton stills with the necessary condensers, separating vessels, and receivers. There is also a room set apart for the manufacture of crude carbolic acid. Adjoining this is the anthracene house, where the heavy anthracene oils are filtered, then pressed by hydraulic power, and the pressed anthracene is packed in barrels and sold to the producers of artificial alizarine. After being treated for carbolic acid the naphthas are passed on to the rectifying house, there to be washed with rectified sulphuric acid and again distilled to produce benzol, toluol, solvent naphtha, and burning or heavy naphtha. This is as far as the process is carried at these works, the further treatment of the benzol being left to the aniline colour makers. The plant for the treatment of the ammoniacal liquor was erected by Messrs. John Abbott and Co., of Gateshead, and consists of two 15-ton stills with their accompanying saturators, settling tanks, and evaporating pans, being on what is known as the close saturator principle. The total quantity of sulphate produced in twelve months is about 320 tons. St. John's carburetter and condenser was also shown to the Members and its action explained.

2. Rochdale Manure Works.

The Members proceeded to the Manure Works, where they were met by Mr. Alderman Taylor, Chairman of the Health Committee, who conducted them through the works, and explained in detail the different stages of the operations now being carried on towards a

solution of that much-vexed question, the Disposal of Town Refuse. Descriptions of the Depot and the character of the work carried on have appeared in previous volumes of the Proceedings (vol. iii. p. 204; vol. v. p. 104), but as considerable changes have been made in the mode of dealing with the excreta and the ashes, the following short description has been prepared. The works are situated about 660 yards from the centre of the town. The closets are on what is known as the Rochdale Pail System, with a roofed ash-place at the back, containing tub for the reception of the house refuse. The excreta pails are removed weekly in specially designed vans, each van containing 24 pails; the full ones on being removed from the closets are hermetically sealed by a cover invented by the late manager (Mr. Haresceugh), and are replaced by clean pails, each having had placed therein a small quantity of deodorant. The tubs containing the house refuse are removed weekly or as required; 8346 tons of excreta, and 15,503 tons of house refuse have been collected this last year, the staff required being 2 inspectors, 33 drivers, 21 conductors, 33 horses. The ashes and refuse are tipped into a shed, containing riddling machines, which remove all the fine ash, which is eagerly fetched by farmers to use as an absorbent in their shippons, and for mixing with liquid manure. The tin cans and similar articles are taken out and disposed of from time to time. The cinders, vegetable, and other refuse, are used solely for generating heat and steam throughout the premises, the clinkers resulting therefrom being ground in a mill with lime into mortar, which has a ready sale and is also used by other departments of the Corporation. On entering the works, the vans, after being weighed, proceed into a large shed, which is hermetically sealed, the two doors only being opened when required for the admission and exit of the vans; the pails are removed from the vans, and placed on a large table of a hydraulic lift, which raises them to a higher floor, where they are emptied into two tanks, when they are returned, and washed, and deodorised, before being placed in the vans, which are also similarly treated after every journey. The excreta is run from the tanks into revolving cylinders, 12 feet long, by 6 feet 6 inches to 6 feet taper diameter. These cylinders or machines, have been designed and patented by Mr. Haresceugh, and are the outcome of several years' experience at these works in attempting to convert the excreta into a marketable manure. The cylinder revolves on four friction rollers, there being fixed inside the cylinder a movable arm or scraper for keeping the mass

constantly in a state of motion, so that the surface of the excreta will be constantly exposed to the hot air, thereby thoroughly drying it. The drying is effected by connection of a large pipe to a boiler specially constructed for burning the cinders and vegetable refuse referred to, the heat as hot air passing through the pipe and through the revolving cylinder or machine, and absorbing the water of the excreta, the effect of which is that a charge of 3 tons 10 cwt. of excreta is reduced in about eight hours to 5 cwt. of material, very similar in appearance to hard dry clay. To each ton of the excreta there is added 20 lb. sulphuric acid, and thus the ammonia is fixed and not driven off by the heat. The heat passes from the machines through flues, is utilised for completing the drying on a drying floor, and conveyed to condensers, which reduce the temperature and drive off the vapoury particles; it is then forced by a blower through a furnace, and finds its way up the chimney. The manufactured product is taken from the machines, placed in an adjoining shed, and ground in a pugmill to a "poudrette."

The following analysis by the borough analysist, shows the composition of the manure:—

ANALYSIS OF ROCHDALE MANURE IMMEDIATELY AS IT LEAVES THE MACHINE.

Moisture lost at 212° F.	23·07
* Organic matter and ammonia salts lost on ignition ..	52·52
† Soluble anhydrous phosphoric acid (P_2O_5)	1·13
‡ Insoluble „ „ „ „	1·63
Anhydrous sulphuric acid (SO_3)	9·16
Potash	3·60
Lime	2·10
Alumina, oxide of iron, magnesia, &c.	3·90
Silica	2·89
	100·00

* Containing nitrogen equal to 6·71 per cent. of ammonia, or calculated to the sample dried at 212° F. 8·73 per cent. of ammonia.

† Equal to 1·84 per cent. of soluble phosphate of lime.

‡ Equal to 3·55 per cent. of insoluble phosphate of lime.

N.B.—Before being sent away the manure is further dried by being spread out on the drying floor as above explained, until the moisture is reduced to about 12 per cent.

As the works are at present in a transitory state, it is almost impossible to say what will be the amount of manure, and the cost of manufacture, but the demand for concentrated manure so far has

exceeded the supply. It is hoped at an early period to give an account of the result of the working of these late improvements. The Members also viewed one of Lyon's patent disinfecting machines which has lately been erected at these works.

Votes of thanks were passed to the Mayor for the use of his reception room, and to Mr. Alderman Taylor, and Mr. T. B. Ball (gas manager), for their kindness and attention to the Members on visiting the manure works and gas works.

WILKINSON'S TRAMWAY LOCOMOTIVE.

Extracted from a Paper read before the Liverpool Engineering Society, 25th April, 1883.

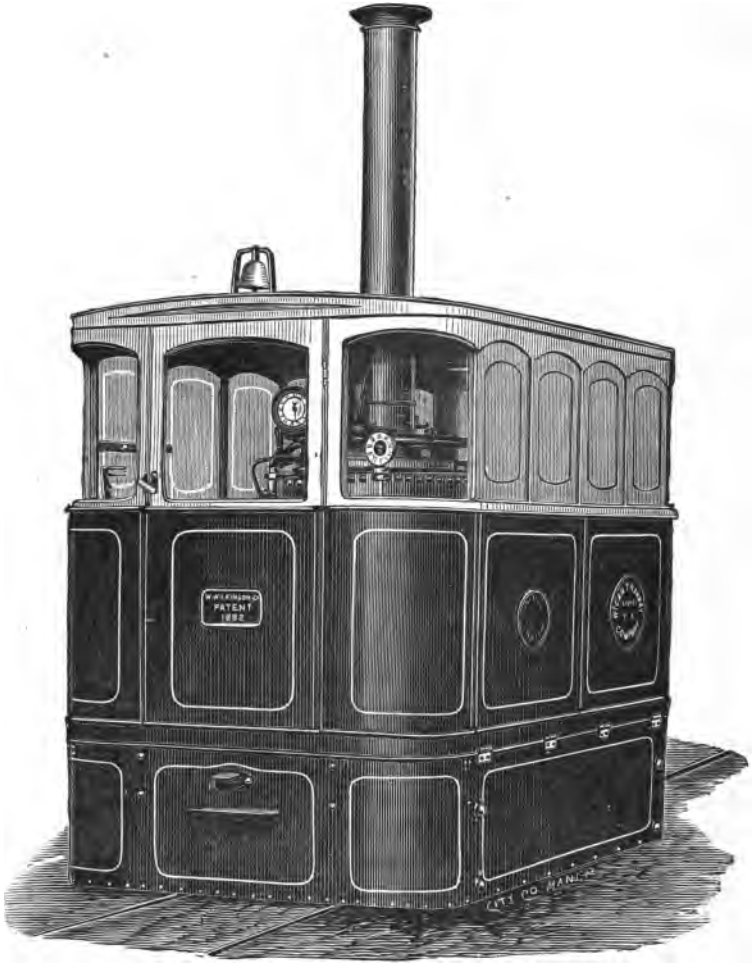
Owing to the ever-varying conditions under which the boiler of a tramway locomotive has to work, due to the sudden changes in the nature of the roads, from dead levels to the steepest inclines (as, for instance, at Huddersfield, from level to 1 in 11½), which does not happen in railway practice (a gradient of 1 in 75 being considered excessive on a railway), the boiler of a tramway engine should be of the most sensitive nature, as one moment it necessarily is not required to generate steam, save in a very small quantity, and in the next it is called upon to work to its utmost evaporative power as above, which sudden requisition obtains more or less on all steam-worked tramways, owing to the before-named sudden changes in levels.

The boiler is an improved Field's patent, viz. vertical, with an internal fire-box, which gives an annular water space all round, between the outside of fire-box plates and the inside of boiler shell plates, as is usual in all vertical and locomotive boilers.

The crown plate of fire-box is perforated with a number of holes, and into each hole is fitted a hanging tube, which tubes are closed at the lower end, and when at work are consequently full of water. These tubes hanging from the crown of fire-box are exposed to the most intense heat of the furnace, which is placed immediately beneath them, and being ⅛th of an inch thick only in section of metal (iron), must necessarily be extremely sensitive generators of steam, and would boil dry intermittently if they were not provided with some appliance to counteract that evil, which is done as follows: Each tube has, hanging loosely inside it, another tube fitted with conical mouthpiece, with three feathers or wings on the underside of cone to preserve an annular space between the top end of the large tube and the underside of cone.

The action due to the natural law (the difference in specific gravity between hot and cold water) that the cooler water always descends to the bottom, is as follows, viz.: As soon as heat is applied to the external surface of the tube which hangs over the

fire, the water in the annular space between the inner and outer tube begins to ascend, and is somewhat deflected by the cone at the top, and the cooler water begins to descend the inner tube, and as the heat is increasing so in a proportionate rate is the speed



of the two currents (ascending and descending) increased, thereby creating a very rapid "circulation" and bringing every particle of water rapidly in its turn into close contact with the fire or furnace, with an interposition of only $\frac{1}{8}$th of an inch of iron between the

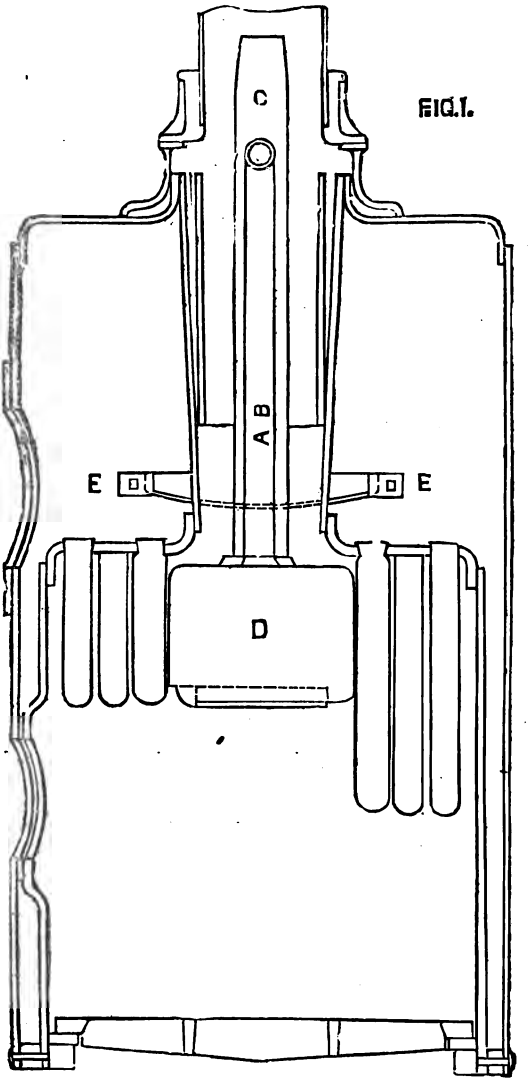
water and said fire. These tubes being fastened only at one end in the tube plate, the other end hanging free over the fire, are at liberty to expand or contract to any extent, and thereby are not in the least affected by unequal and varying temperatures as in the locomotive type of boiler, where the tubes are secured at each end in a rigid tube plate, and are a constant source of annoyance in small locomotive boilers, by the fire-box tube plate becoming leaky after a few months' service, these leakages never, under any circumstances, happening in this boiler. Whenever the boiler should happen to get short of water through carelessness and inattention, the crown plate of fire-box is the first part to become exposed, and consequently the tubes will boil dry at once, and being so much thinner in section of metal than the tube plate, coupled with the fact that they are so much nearer the fire, the consequence is, that one or more of them will simply tear open at the lower end and allow the steam and a little of the water to escape harmlessly and put out the fire at once before the crown plate can become overheated and do any damage. This type of boiler can be examined in every part *by the eye*, and can be got at easily *by the hand* in every part for cleaning thoroughly, which cannot be done in the locomotive kind, where trust has to be put to "Providence and a hose pipe" for cleaning.

Inside the boiler at E E, Fig. 1, is fixed a loose dish to catch any hard mud or scale which may from time to time drop from the uptake at the water level where such mud often accumulates, and dropping off into the conical mouth of internal tubes, impedes the free circulation of the water, and causes damage to the outer tube by burning.

Further, this boiler has been well tried and tested under the most extreme pressure of hard firing for sufficient length of time to establish its lasting qualities: i. e. the Leeds and Liverpool Canal Company have fourteen of these boilers fitted on steamboats carrying goods between Liverpool and Leeds (128 miles by canal); each boat runs twenty-four hours per day, the boilers being fired to the utmost capacity of their evaporative power, with a much stronger blast and forced draught than is ever required for tramway purposes, and are entirely in the hands of the most inexperienced men, viz. the ordinary canal boatmen (no engine-men being carried, each boatman attending to the engines in his turn whilst the others sleep), consequently the boilers are doing two ordinary weeks' work in one, with a most excellent result, some of

them having been in regular work since *May* 1879, up to date, say four years, or eight years' ordinary work of twelve hours per diem: which is a fair test of their lasting properties.

FIG. I.



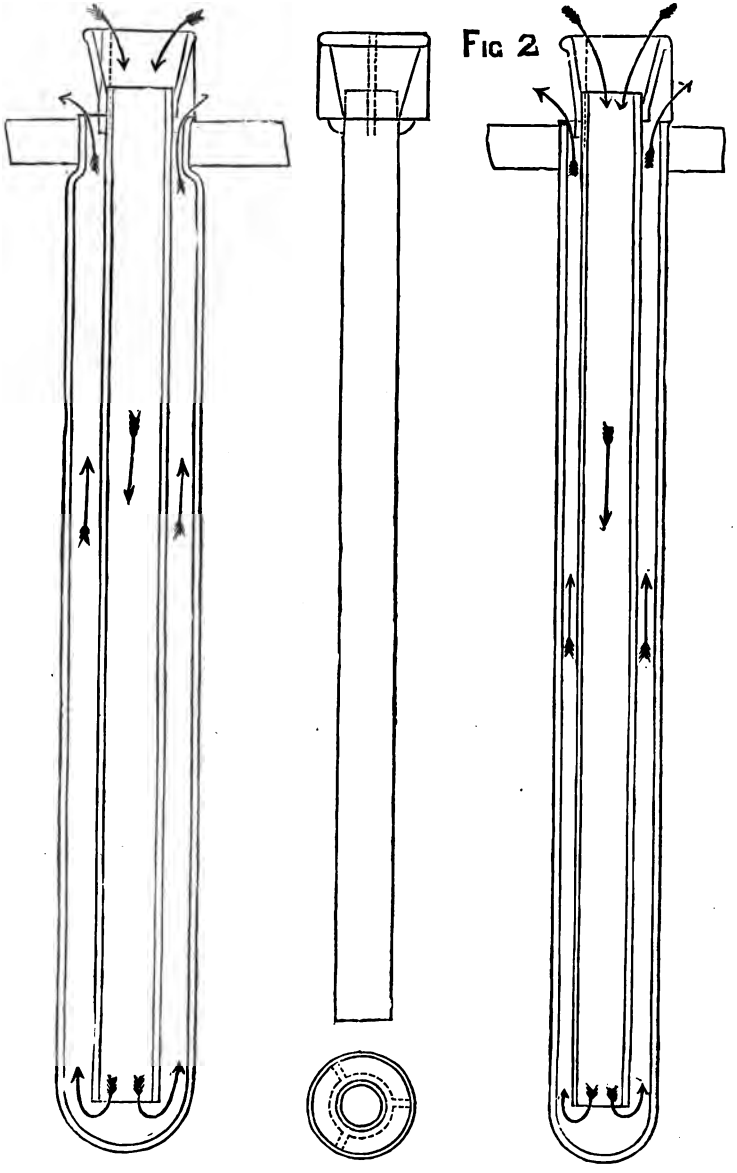
The centre of the fire-box is necessarily open to the uptake or chimney, and the flame and heated gases would thereby pass rapidly

away; but, to prevent this, and to distribute them amongst the tubes, this open space is partially blocked up by a cast-iron chamber or superheater D, Fig. 1, into which the exhaust steam is led by the two pipes A and B, Figs. 1 and 3 (one from each cylinder), consequently (this chamber being always at a very high temperature, owing to its near proximity to the furnace) the steam is dried, and also superheated and rarefied to a high degree after leaving the cylinders, and immediately before it issues into the atmosphere up the funnel by means of the pipe C, Figs. 1 and 3, and when passing up the funnel has to intermix with the whole volume of heated gases from the furnace; at the same time its velocity upwards sets up an induced current and causes a strong artificial draught in the furnace.

The waste steam from the safety valves is also led by the pipes A and B to the superheater D, Figs. 1 and 3, and undergoes exactly the same process as the exhaust steam does. The superheater D, Figs. 1 and 3, has a conical pipe cast in its lower end, projecting upwards, and passing up the inside of the exhaust pipe. This pipe is enlarged at its lower end, and is fitted with a perforated grating or grid, made from cast iron, fire-brick, or any refractory material, to arrest sparks; inside this pipe is fixed a steam-jet pipe, so as to be either in direct communication with the boiler or coupled to the main steam-pipe, between regulator valve and cylinders, at pleasure. In direct connection with the steam supply for this jet is another circular ring or jet, consisting of a pipe bent round the mouth of the blast pipe, and perforated on its upper side with a number of minute holes.

These steam jets when open cause a strong induced current of heated gases from the furnace to issue from the mouth of the internal pipe, which is just level with the end of blast pipe C, Figs. 1 and 3, the two pipes forming an annular space from which the exhaust escapes, the heated gases being injected right into the centre of said space, and thereby mixing thoroughly with the already superheated steam (the ring jet causing a current externally) in such a manner as to render the steam invisible when issuing from the funnel into the atmosphere, except under the most abnormal states of the weather, say frost and fog or snow combined.

The annular space inside the uptake is filled with fire-clay, which protects the boiler plate from the action of the flames, *above the water-line*; this action has always been a source of trouble in all



other vertical boilers at this point, causing rapid deterioration, but has been effectually dealt with by placing this fire-clay non-conductor here as shown.

In case a tube "burns out" it can easily be replaced by any ordinary labourer or engine-man at a very insignificant cost.

Fig. 2 is a section of crown plate of fire-box with both internal "circulating" tube and outer tube *in situ*.

The exhaust steam, before being led into superheater D, Figs. 1 and 3, by pipes A and B, Figs. 1 and 3, is passed through a box or vessel, F, Fig. 4, on each side of boiler, which intercepts any water, due to condensation, from the cylinders, which water is led to the ground by means of two pipes, each provided with a stop-cock. Each cylinder has a waste water-cock and pipe leading also to these boxes.

The engines are of the ordinary "inverted vertical type," with link-reversing gear, which gear is acted on by the automatic governor, as follows, viz.: When the regulation speed allowed by the Board of Trade is exceeded, the governor opens a steam valve on the boiler, and admits steam to two pistons; one *reverses the valve gear* of the engines, and the other applies a *brake to the wheels*, both acting in concert and simultaneously.

Under the control of the driver is a powerful steam brake, which can be brought instantly into action on the wheels of the passenger car.

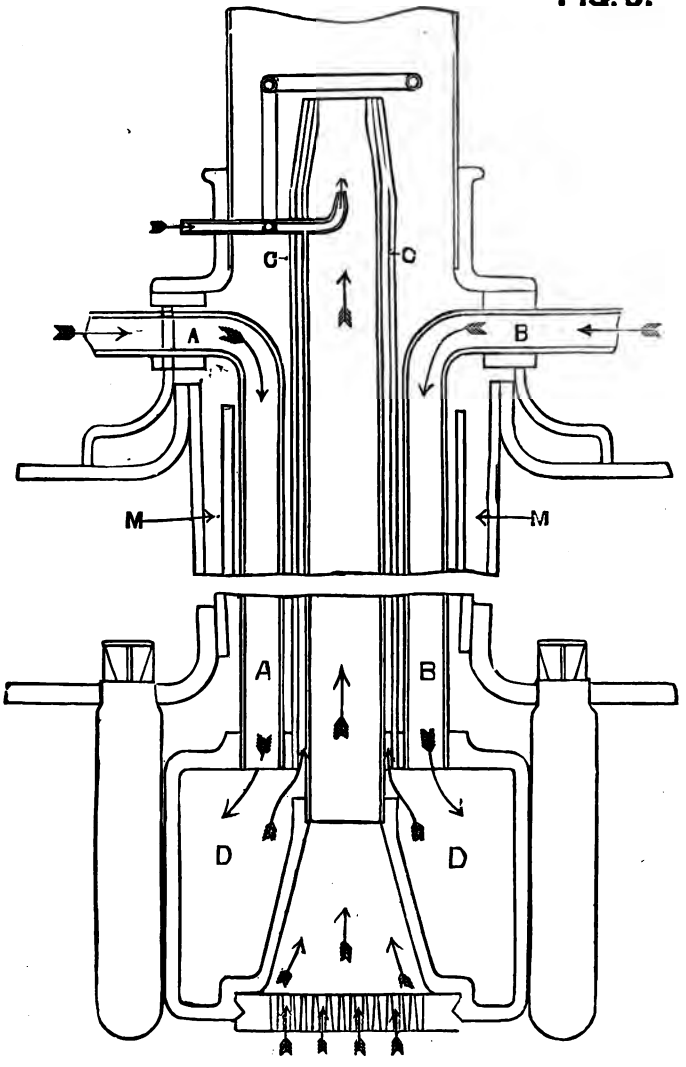
The steam pistons in this engine are not connected directly to the driving axle as in the "Locomotive Tram Engine," but act directly on a crank shaft, G, Fig. 4, fixed in rigid bearings attached to the frame plates. On this crank shaft is fixed a spur wheel, H, Fig. 4, which gears into another spur wheel, K, Fig. 4, keyed on the driving axle, which axle has a pair of the running wheels, L, Fig. 4, for the road, keyed one on each end, these wheels being coupled in the usual manner to the leading wheels by means of the usual coupling rods and outside crank pins.

This arrangement of spur wheels is a departure from all practice which has gone before for tramway or other geared road engines, inasmuch as they are placed in the *centre* of the axle and *round* the teeth transversely across their length, which allows for one end of the axle to lift or fall, as the inequality of the road demands.

In all geared engines hitherto used the spur wheels have been invariably placed on *one* or *both* sides of the engine, with the result (owing to the unequal action of the springs on each axle box, caused by the unevenness of the track or line bringing such a powerful cross strain on the spur wheels) that there was constant repairs and renewals of said gearing required; whereas, in this case, with the

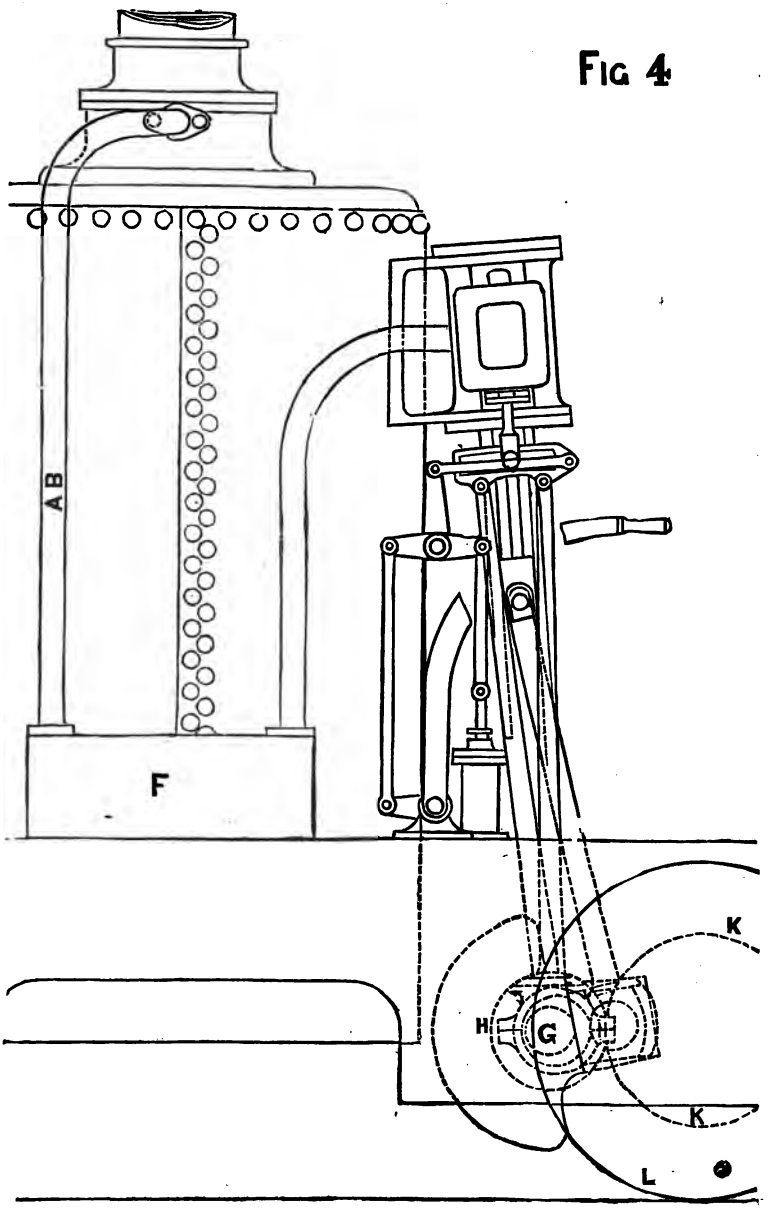
spur gear in the middle of the length of the axle and with the rounding lengthwise of the teeth, this source of trouble is reduced to a minimum, never having had a wheel broken or damaged so far.

FIG. 3.



Hitherto the spur wheels have been made of solid hammered scrap iron forgings, machined all over, with the teeth slotted out of

FIG 4.



the solid metal, and in no instance has there been a single accident with any of them; but to increase the wearing properties they are

now made in forged Bessemer steel, with the teeth cut out of the solid as in the iron ones.

Owing to the driving power being applied in the centre of the length of the axles, and the forces applied vertically instead of horizontally, there is no side to side oscillation of the engine on the road, which is strongly developed in the ordinary locomotive type of tramway engine, and which, as all tramway engineers well know, is so destructive to the permanent way, especially if not in the first instance laid specially for steam purposes. Another feature is, owing to the fact of the boiler being vertical, there is more range in the water space allowable, and the level of the water is not interfered with so much as in the locomotive kind, when ascending steep gradients, and the water range being so great, it does not necessitate the feed being put on when going up a hill, consequently steam can be easily maintained up to the maximum pressure on the steepest inclines; for instance, there is daily being worked an incline of 1 in 11½, about 400 yards long, with a large inside and outside car with fifty passengers, in the town of Huddersfield, and one of 1 in 13, 880 yards long, at Nottingham, with engines weighing only 8½ tons in working trim, starting and stopping on any part of the gradient as required.

The spur wheel on crank shaft being less in diameter than the wheel it drives on the axle, there is a gain of power, and the moving parts of the engines, viz. pistons, connecting rods, guides, &c., are not required to be of the same strength and weight as if coupled direct; further, there is an almost absolute immunity from "slipping" of the driving wheels, as with this engine it is almost an impossibility to cause "slipping," save and except under the most extremely abnormal state of the rails (say snow and frost combined), whereas this "slipping," which is nearly always present in the ordinary loco type of tram engine, owing to the generally greasy state of the rails, is such a frightful source of expensive repairs owing to the racking strains caused by it on all parts of the mechanism. The result of this immunity from "slipping" is that the same amount of work can be done with an 8½-ton engine as can be done with a 12- or 13-ton engine of the loco kind, consequently there is a saving in wear and tear of the permanent way.

In reference to the non-slipping properties of this engine, it is not intended to convey the impression that there is *no slipping takes place whatever;* the wheels *do* slip under abnormal states of the rails, but the slipping is of a *slow* kind, in contradistinction to

the flying round of the wheels of the direct-acting locomotive; this slow slipping is owing to the intervention of the gearing wheels causing such an increase in the piston speed in proportion to the speed of the road wheels revolutions, that the steam from the boiler cannot follow up the pistons fast enough to maintain sufficient pressure to accelerate their speed above a certain point; with the attainment of this result in view, the steam pipes between boiler and cylinders are made so small that they will just give the full boiler pressure on the pistons when going slowly up the steepest gradients with a slow speed, but will not do this when any attempt at slipping is made, which accelerates the piston speed above the ordinary working rate. Further, with the connecting rods (as in the locomotive proper with outside horizontal cylinders) connected direct to the crank pins, and when at their greatest angle from the centre line, say when the crank pin is on the bottom centre, midway between the dead centres, the tendency is to lift the wheel, axle, and axle box off the rail, momentarily, easing the adhesive load from the rail and setting up the first elements of a slip, which is more and more augmented as the speed of the slip increases, inasmuch as the pulsations are so rapid that the weight of the engine as a whole has not time to re-act through the medium of the springs. This is entirely overcome in the engine under notice by the steam acting on an independent crank shaft carried in rigid bearings which are self-contained with the cylinders.

The intervention of this gearing has another good property, inasmuch as in the ordinary working of tram engines the stoppages have to be made in many cases very suddenly, which in this case is done by simply reversing the valve gear without putting steam against the pistons, which act is in itself enough to "skid" the wheels, owing to the smaller wheel on the crank shaft having to be driven round by the larger wheel on the driving axle, the resistance of the pistons, caused by the amount of compression in the cylinders, being thereby multiplied exactly as the power is multiplied in driving the wheels in the right direction.

The general construction of the framing of engine, the wheels, axles, axle boxes, guard plates, &c., are similar to the loco type of engine. The fire-boxes, are "Farnley," or "Low Moor" iron, frames are "B. B. Staffordshire," all bearings and engine brasses are "phosphor bronze," and exceptional care is taken in the workmanship all throughout to ensure its being well done.

The whole machine is cased in with a wrought-iron casing with

loose window-frames, which can be moved at pleasure according to the state of the weather, and the engines are fitted with duplicate regulators and reversing levers, also with steam brakes for the cars under the control of the engine-driver, and injectors, so that they can be driven from either end, in which case the engine-man always stands at the *front right-hand corner* of his engine, whichever way it is running, giving him a good clear view of the road ahead of him.

The wheels have steel tires 2 inches thick, and also steel crank pins for the outside coupling rods; the axles, slide bars, piston rods, crank shaft and cross-head centres are steel, the valve motion "Low Moor" iron, case hardened, all bolts and nuts are steel, turned to fit in bored and reamered holes.

DISTRICT MEETING AT MIDDLESBROUGH-ON-TEES,

June 23, 1883,

Mr. Charles Jones, *President, in the Chair.*

The minutes of the previous meeting having been read and confirmed, the President referred to the intimation that Mr. Thomson had given of his desire to resign the Hon. District Secretaryship, but trusted that that gentleman, who had given every satisfaction, would reconsider his intention. And in case the next Annual Meeting should be held in the North, Mr. Thomson's services would be most valuable to the Association.

Other speakers having expressed the same views, Mr. Thomson stated that he had not discharged his duties to the district as he should have liked, owing to the increase of official duties, but if the next Annual Meeting were to be held at Newcastle, he would be willing to remain in office till after that event.

The President said the first subject for consideration was the *résumé* of a discussion on Mr. James Hall's paper on

APPORTIONMENTS OF PRIVATE IMPROVEMENT WORKS.*

The President: Perhaps Mr. Hall will kindly preface the discussion with some remarks by way of a beginning.

Mr. James Hall: I have very little to say. I would, however, draw attention to the Public Health Act Amendment Bill. There are several clauses in that Bill which would, I think, be the better for amendment. Last year, Mr. President, you made reference to such a measure, and said that it would be well, in framing it, to

* This paper was read and partly discussed at a District Meeting held at Sunderland, April 22, 1882. See vol. viii. of 'Proceedings,' p. 70.

have the opinions of practical men. In the framing of the new Bill it would have been better if this had been so. Mr. Thorrold and myself have received printed copies of the Bill, but in view of this meeting we have taken no action. I trust it will be discussed at the next meeting at Oxford, for the Bill as it now reads gives facilities for the people to object to improvements suggested by Health Authorities. With regard to my paper, I have not altered my opinion. I still hold that it is just and right for each property owner to pay for private street improvements according to the frontage of his property. I shall be glad to answer any questions on the paper.

The PRESIDENT: Some of the questions referred to by Mr. Hall will be taken up at the Oxford meeting.

Mr. JAMES HALL: We have never had the difficulty of unequal streets.

Mr. HOWCROFT: Looked at in respect to a street of unequal width, it is questionable if the owners should not pay according to the superficial area. Such a case has come under my notice, and I thought the owner should pay in that way instead of according to frontage.

Mr. THOMSON, after quoting part of the 150th section, Public Health Act, said: The matter, according to my thinking, is clearly defined thereby, as all the people in the street have a right of way over it, and consequently ought to pay according to their frontage; and the only difficulty is with regard to the piece at the junction of four streets. The contention is, whether it should be charged to the whole street, according to the frontage, or to the owner of the adjoining property.

Mr. JAMES HALL: The owner of the property at the corner should only pay for the street mentioned.

Mr. THOMSON: And where four streets end?

Mr. HOWCROFT: Charge it on all the owners.

Mr. JAMES HALL: That's the method I adopt.

Mr. HOWCROFT: The authority should make the crossings.

Mr. JAMES HALL: In Stockton all the streets are paved.

Mr. HOWCROFT: I mean in cases where the streets are macadamised. In the event of a square, with a wall at one end, should all the owners pay according to frontage?

Mr. STAINTHORPE: Have you had such a case?

Mr. HOWCROFT: Yes.

Mr. STAINTHORPE: It is very unusual.

Mr. HOWCROFT: I think they should so pay, though some owners think it hard, although having no right of access. They could break a door through the wall after dedication to public use.

Mr. PETREE: I divide all round to the total length, and make all pay.

Mr. HOWCROFT: That is what I do, but I wish to hear what others do.

Mr. STAINTHORPE: I have read Mr. Hall's paper, and I think his mode of apportionment is just.

Mr. JAMES HALL: We always charge all private street improvements according to the frontage.

Mr. STAINTHORPE: But you charge the sewers separate?

Mr. JAMES HALL: Only the surface drainage is charged with the other improvements.

Mr. STAINTHORPE: I think the charge of 5 per cent. is not general.

Mr. JAMES HALL: It is general with us. We made a profit one year of 500*l.*, but we had done some large works. It paid all the office expenses for one year.

Mr. THORROLD: I think Mr. Hall's plan is the best, if there had been no difficulty in the Act. It has, however, been clearly laid down that the improvements should be apportioned according to the width of the street. With regard to the cross streets, there were many opinions, some saying that the work should be charged to the rates, and others to the owners. There was one very important point which had not been touched upon, and that was, Had the magistrates any power to inquire into the charges? It has been held by the highest authority that they have not, and there is nothing in the Act to support such a claim. I am astonished at some magistrates wishing to make an authority prove a whole case. It is very difficult, if not impossible, to tell where every sixpence has been spent in making a number of streets.

Mr. JAMES HALL: By the proposed act the approximate estimate must be served on each owner; but if you post a notice at the end of each street, it will be considered sufficient; but there is an objection to that mode. There are other powers. In laying out an estate you may compel the owner to open out, flag, &c., the street before the houses are built, if once an estate plan is submitted and approved.

Mr. STAINTHORPE: In the event of property changing hands during the progress of the work, who is responsible for the payment?

Mr. JAMES HALL: Whoever has the property when the apportionments are served.

Mr. M. HALL: The person who holds the property at the time the apportionments are served is responsible.

Mr. PETREE: The only thing that prevents the taking up of Mr. Howcroft's idea is that people have the choice of doing the work themselves. It is very unjust, and the best way is to apportion the rest among the whole of the owners.

Mr. M. HALL: We charge crossings and all works of general utility to the rates; it is a good plan, and has worked well.

Mr. THOMSON: Mr. Thorrold has proved that that is wrong.

Mr. STAINTHORPE: It has not been disputed.

Mr. M. HALL: Who is there to dispute it?

Mr. STAINTHORPE: Some cantankerous ratepayer.

The PRESIDENT: I am very sorry that the Bill referred to by Mr. Hall has not been discussed before. It is very important, many of the clauses having an injurious tendency. I trust, however, it will have every attention. With regard to Mr. Hall's paper, I have read it and the discussion, and I think it has been well considered. It might do to charge the cost of making the crossings to the rates, but then, as had been said, some cantankerous ratepayer might object. There was also a difficulty in the way of making all pay according to their frontage, for there was no power to compel a man to pay for 30 feet of road when he had only 15 feet. The question of the interference of magistrates was an important one. They had no right to interfere, and it was not fair to compel a surveyor to go over all the accounts for the amusement of two or three counsel.

Mr. JAMES HALL: I am well pleased with the result of the discussion. It has been fair and I trust interesting, and the very fact that we have differed shows that we are alive to the importance of the question discussed. With regard to an owner doing his own work, it is not imperative that the authority should take the street so done over, and can, if necessary, compel him to do the work over as often as required. There is another question that is worth full consideration at Oxford, and that is the question of footpaths abutting on highways. If I am correct, there is an old Act, not yet repealed, which provides for the making of such footpaths, one side by the authority and the other by the owner. That is a matter which should be ventilated as much as possible.

THE STATUS OF THE LOCAL GOVERNMENT BOARD SURVEYOR.

By T. W. STAINTHORPE, Surveyor to the Urban Sanitary Authority, Loftus.

In introducing this subject for consideration, the author is somewhat at a loss to clearly define the professional position or status of the Local Board Surveyor, or to show the estimation which the general public place upon the duties of his office.

To begin with, the Public Health Act 1875, by Sec. 189 enforces the employment of a Surveyor by every Urban Sanitary Authority or Local Government Board for their respective districts. It is fortunate that the above section is compulsory, for had it not been so the author is of opinion that many of the smaller Urban Authorities would not trouble themselves to employ such an official, but would rather prefer the duties to be discharged by perhaps the most learned of their highway or scavenging staff, provided that his services could be secured at an economical rate. This statement may appear rather sarcastic, but the author can vouch for its veracity so far as two Urban districts are concerned with which he is acquainted. It is satisfactory, however, to note that the majority of Local Boards of any importance do not carry out such a narrow-minded policy.

The author need not here dilate upon the absolute necessity or importance of Local Authorities employing men who are fully competent to act as Surveyors, for any man of experience must have seen the deplorable results of engaging men whose greatest recommendation has been their cheapness and a willingness to act as mere tools in the hands of their employers. The most important point the author wishes to draw attention to is the glaring fact that whereas every profession of importance has its examination and standard of fitness, there is at present no such examination required in order to certify that the candidate is duly qualified and competent to undertake the office of Surveyor and Engineer to any Urban Authority.

Looking at the responsible, onerous and important duties which a Surveyor—in the true sense of the term—has to perform, it does seem strange that some suitable test of his fitness for the duties devolving upon him should not be compulsory before he is allowed to undertake such duties.

The author cannot see why the Local Government Board in London do not apply a similar rule to the appointment of Surveyors as is applied to Medical Officers of Health, it being a *sine quâ non* that the latter officials must be duly qualified medical practitioners before their appointments can be confirmed.

Surely if it is necessary in the latter class of officers, it should be equally incumbent upon the former, to show some approved diploma of their ability.

The author is aware that the Sanitary Institute of Great Britain professes to hold periodical examinations, and to grant certificates of competency to Surveyors and Sanitary Inspectors, but so far as he is able to judge, something more is required than the answering of such questions as are usually set forth upon their examination papers in order to become a Surveyor, duly qualified in reality as well as in name. *En passant* the author may state that the collective composition of the examining body of the above Institute is strongly objected to by many good Surveyors for reasons which he does not care in a paper of this description to enter into.

The author has no statistics of the number of candidates who have presented themselves to this Institute since its formation for examination, but does not think that any man who has been regularly trained to the profession will place any great value upon the certificate or ticket that the above Institute may bestow upon the successful applicants.

The result of the profession being without an examination of a suitable nature is constantly seen in the numerous applications which are sent in whenever there is a vacant surveyorship advertised, emanating from joiners, bricklayers, broken-down contractors, time-keepers, and others, who in their own estimation think themselves fit and proper candidates for such vacancy.

As a comparison to this wretched state of matters, what would the members of this Association think if the same individuals applied for the office of Town Clerk or Medical Officer of Health? In many cases, no doubt, they would be as equally capable for the one office as the other.

What can be more annoying or disheartening to the properly-

qualified Surveyor who in applying for a surveyorship finds that he has to compete against such a conglomerate lot of individuals, and who, perhaps, often learns to his sorrow that his training and abilities avail him nothing when one of the above-mentioned competitors or some such like local nonentity happens to be a personal friend or relative of some of the powers that be.

This is really an important matter, and one that has a direct bearing upon the welfare of every competent Local Board Surveyor in the kingdom, and until some suitable examination is made compulsory by the Legislature, the author is afraid that the unfair and unlimited competition indicated above will increase instead of diminish, and thus cause the poor unfortunate Surveyor to labour all the best years of his life for what, in many cases, is financially no better than what he could have earned, assuming he had been employed as a foreman mason or bricklayer.

The author has said, the best years of his life, for he knows of good men who, having applied for appointments, have been left out in the cold simply because they were on the wrong side of forty years of age.

In this respect the Surveyor compares very unfavourably with Poor Law and Civil Service officers, who, when they have worked a certain number of years, are rewarded by a generous nation with a handsome pension for the remainder of their lives.

The author is inclined to think the salaries of surveyors should be paid entirely by the Local Government Board, so as to make them thoroughly independent from any local preponderating influence whatsoever. This arrangement is already partially carried out and recognised by the above Board, who pay a certain proportion of the salaries of Sanitary Inspectors and Medical Officers of Health out of moneys voted annually by Parliament for that purpose.

The question also of granting legal protection to the Surveyor who satisfactorily performs his duties (which is at present denied, and already enjoyed by the Sanitary Inspector) is also a matter which undoubtedly militates against the stability and professional position of the Surveyor. As an act of common justice, some amendment in this respect is absolutely necessary.

The author ventures to say that unless some steps are taken to improve and strengthen the position of the Local Board Surveyor, so as to give him a recognised status and protection as a professional man, the important duties of his office will in the future

have to be discharged, not by men of practical training and education, but by others whose fitness for the duties will be in proportion to the small salaries which unchecked competition must eventually create.

There are many other points which the author would liked to have touched upon, but thinks that sufficient has been said to prove that the profession is on a very unsatisfactory basis, and that there is plenty of scope for improvement if the Surveyor of the future is to assert the important position as a professional man to which he should be and is justly entitled to occupy.

In conclusion, the author trusts that the members of this Association will not think this subject—which he cannot do justice to—beneath their notice, and if in any form or shape some pressure could be brought to bear upon the Local Government Board to give the same their earnest consideration, with a view to improving the status of the profession, he will be amply repaid for any little trouble that he has undertaken.

DISCUSSION.

The PRESIDENT: We shall be glad to hear any remarks on this paper.

Mr. PETREE: In my opinion there is nothing that would do more good than for the local surveyor to be paid entirely by the Local Government Board. As it is, property owners, in the shape of builders, make it little better than hell upon earth for some surveyors. This is rather strong language, but it is expressive, and it would be the same for the Medical Officer and Sanitary Inspector had they not been protected. With regard to the examination, I do not think it would do much good, as "crammed" competitors might be able to turn aside really able men.

Mr. JAMES HALL: I entirely dissent from the idea of holding examinations. There are many able men who would not "cram" for an examination such as the Sanitary Institute provides. One of my young men has prepared for it, and his general reading did him good to a certain extent; but there is very little that is practical in it. With regard to the salaries of surveyors, it is natural for authorities to think that they can get men at almost any price. There is hardly an appointment worth 100*l.*, but there are four score of applicants for it. Many of these have been or are surveyors, and so it happens that authorities think that the supply is

large. But is that the case? I do not think so. Many of the candidates send in their applications merely to see what chance they stood in applying for such a place. Others apply for a love of change. If surveyors would but look to their own interests, it would be the best means of raising the status of all.

Mr. THORROLD: I agree very much with Mr. Hall, and fail to see the utility of an examination. If such an examination only taught surveyors the manly art of self-defence—for they have frequently almost to box for an existence—it would do some good. I do not know how some people expect surveyors to exist on the salaries offered, or how they can expect other applicants than the worn-out constable or broken-down gardener. I think the best way for surveyors to raise their status is to attend to their own districts. I have known a surveyor with 150*l.* a year apply for a situation in a district where the salary was only 100*l.* Surely he applied merely to see what chance he had.

Mr. J. HALL: The best test of a man's ability is for the authority to send a committee to examine the districts managed by the applicants.

Mr. THOMSON: That would be the most satisfactory.

The PRESIDENT: I have always taken a great interest in this subject. The examination of the Sanitary Institute is simply nonsense, and has evidently been drawn up by some person who has no practical knowledge of the work of a surveyor. An examination is only a means to an end. The best course for a young man is to serve an apprenticeship in a good office.

Mr. STAINTHORPE: I am glad you all fall in with my ideas with regard to the want of protection, for we all require it. With regard to there being some check upon the employment of unsuitable men, I am still of opinion that something should be done in that direction, for in many cases the applicants for the post of surveyor are not professional men at all. I think the Government should insist upon the appointment of professional men, and in the case of small authorities, unable to employ such a surveyor, the Government should amalgamate two or three of them together.

Mr. J. HALL moved, and Mr. Thorrold seconded a vote of thanks to Mr. Stainthorpe for his paper, which was carried by acclamation, and duly acknowledged.

The Secretary read a letter from Mr. Vawser, suggesting an alteration of Rule V.

The matter was discussed, but as the subject was to be brought

before the Annual Meeting at Oxford, it was thought desirable that no opinion should be expressed by this meeting.

A hearty vote of thanks to the President was proposed and carried unanimously, for his having at considerable expense and sacrifice of time presided at the meeting.

The Members were hospitably entertained by the Tees Scoriæ Brick Company. At luncheon, Mr. John Dixon, the genial Chairman of the Company, presided, and there were also present Mr. C. Moses (Vice-president), Mr. G. Watson, J.P. (Director), Mr. C. J. Dobbs (Engineer), and Mr. T. R. Dent (Secretary). Afterwards the Members, accompanied by the gentlemen just named, visited the Cement Flag Works of Mr. A. J. Jones, at Middlesbrough, and were also conveyed to the works of the Tees Scoriæ Brick Company, at Stockton, where the whole process was viewed. On the motion of Mr. Jones, seconded by Mr. Jas. Hall, a hearty vote of thanks was awarded to the Tees Scoriæ Brick Company for their kind hospitality.

ANNUAL MEETING IN OXFORD,

June 28, 29, and 30, 1883.

ADDRESS OF THE PRESIDENT,

W. H. White, M. Inst. C.E., Local Board, Oxford.

Gentlemen,—I beg to return you my sincere thanks for the high honour you have conferred upon me in electing me President of the Association for the ensuing year, and at the same time to offer you a hearty welcome to Oxford.

When I look back at the names of the nine able men who have preceded me in the chair (two of whom have, to our great loss, been lately taken from us), I cannot but feel some distrust of my own fitness to take up and carry on their work.

I am, however, sure that I shall have the willing co-operation of of the past Presidents and Council, so that with such help, coupled with close attention on my own part to the business of the Association, and with an earnest desire to advance its interests and increase its usefulness, I may be enabled to give a good account of my duties.

You have heard from the report of the Council of our continued progress and prosperity. We have to congratulate ourselves on our increasing numbers, but still, when we consider the small proportion they yet bear to the total number of those eligible for membership, the desirability of every Member doing all he can to bring others in is very apparent.

The stronger we become in numbers the more solid will become the "concrete mass" spoken of in the Inaugural Address of my immediate predecessor, and the more we shall be able to achieve.

Without being charged with undue laudation of the work of our Association, I may be permitted to assert that, young as it is in comparison with many other technical societies, our meetings and discussions, and the publication of our Proceedings have not only conduced to the interchange and extension of our own knowledge

and to the elevation of our professional status, but also that they have not been without influence upon public opinion on sanitary matters, even beyond the limits of this country.

In these days, when we find so many societies, more or less influential, directing public attention to the importance of sanitary science, legislation going on in its interest, and even a Royal Prince most ably advocating its claims, there appears to me to be some danger of the honest zeal for improvement which undoubtedly exists producing a reaction from the old-fashioned indifference into the opposite extreme of crotchetiness, resulting from imperfect knowledge.

That this danger is recognised by higher authorities than I, is shown by a saying of Mr. Rawlinson a year or two back, that "half knowledge had been said to be worse than ignorance, and this half knowledge on sanitary matters is very common"; and again, by a remark recently made by the President of the Local Government Board, that "it is one of the dangers of sanitary science that everybody thinks he or she knows something about it."

Now, without reflecting in the least upon the work of other bodies or persons, it seems to me that even on account of the existence of the danger alluded to, if for no other reason, there is much need of the guidance which can be afforded by an association such as ours, composed as it is of men who, from the circumstances of their training and practice, may fairly claim to be specially skilled in works conducive to public health.

Let us therefore, while not neglecting our own professional interests, continue to recognise the important duty of stimulating the modern tendency towards sanitary improvement, and also, where necessary, of restraining it within the limits of practical usefulness and common sense.

I look forward with some degree of hope to a time when the assistance of the Association will be sought in framing those measures, the carrying out of which is placed so much in the hands of the Members, and I venture to think that if this anticipation be verified, the acts regulating municipal and sanitary works will become more easily workable than they have hitherto proved.

Several Acts and amendments of existing Acts upon matters coming partially or wholly within the scope of our work were passed during the Session of 1882, viz.:—"Artizans' Dwellings," "Electric Lighting," "Municipal Corporations," "Baths and Wash-houses," and "Highway Rate Assessment."

There is also now before Parliament a bill making important amendments in the "Public Health Act" as to works of "Private Improvement."

I do not propose to volunteer any opinion upon these Acts, but there will be, at all events with regard to the last named, early opportunities of eliciting the opinions of the Members generally.

There are doubtless many other amendments which will occur to you as desirable in the future. Among these we may perhaps eventually see a measure giving the surveyor a right of appeal against injustice such as we know has in some instances been practised towards him.

The remedy for the evil is not, however, in my opinion, so simple as it appears.

The right of appeal certainly seems good in principle, but I have not yet been able to assure myself that even a successful issue from such appeal could so effectually set the surveyor right with his masters as to enable him to continue his work under them with anything like peace and comfort.

In addition to the consideration I have named, the effects which many of us already experience of the existing tendency towards centralisation in the administration of local affairs, should at least make us careful how we encourage its further development.

Government control may be carried too far, and on the whole, may not be to our permanent advantage.

But, whether or not legislation of the kind indicated ever take place, we may reasonably hope that the increasing appreciation of the importance of sanitary work, even in the smallest communities, may in time lead to a better appreciation of the surveyor who carries out that work, and that faithful service rendered by him may in all cases be requited by equitable treatment of him.

The Council has lately caused to be circulated a list of subjects on which communications are invited. Many of those subjects have never been brought before the Association, but I feel sure there are those among us who can, if they will, contribute papers upon them of the same high character as many that have already appeared upon other subjects in our volumes of Proceedings.

I trust there will be a good response to the Council's invitation, and I would suggest the addition of the following to the list before given, viz.:—Setting out of Works underground, Subsoil Drainage (urban and agricultural), Public Bathing Places, Public Cemeteries, Hospitals for Infectious Diseases, and Appliances for Disinfecting.

These matters come within the practice of many of us, and papers upon them would, I think, be of interest to most of the Members.

There are many other subjects upon which I might touch, but even a Presidential Address has limits which ought not to be overstepped.

I will therefore now proceed to describe those local works upon which your judgment is invited.

I do not profess that they contain much that is new in principle, or that they are at all on a par with what you have seen in larger and busier towns than Oxford, but still they may be of sufficient interest to justify the expenditure of time required for their consideration.

The district of the Oxford Local Board covers an area of 3540 acres, more than one-third of this area being below flood level. The length of streets and roads repairable by the Local Board within the district is 35½ miles, 29¾ miles of which are macadamised, and 5¾ miles paved. The Board also repairs eight miles of macadamised roads outside the district. There are two miles of private streets within the district. The number of dwelling houses is 8000, the estimated population is 41,000, and the rateable value is 196,699*l*. The increase under these respective heads since I entered upon my office in 1871 has been approximately as under:—

In area of district	12 per cent.
In length of streets and roads repairable by the local board (within the district)	54 „
In ditto, if the roads outside the district are included in the calculation	88 „
In number of dwelling houses	30 „
In population	24 „
In rateable value	54 „

The principal materials used here for macadamised roads are:—

Hartshill stone, which costs, broken to 2-inch. gauge, and delivered on the road	9*s.* 6*d.* per ton.
Clee Hill granite „ „	14*s.* 3*d.* „
Stony Stanton granite „	12*s.* 9*d.* „
Mendip limestone „ „	9*s.* 3*d.* „
Local limestone „ „	5*s.* 6*d.* „

The cost of new roads made to the requirements of the Board, i. e. a foundation of local stone on edge pitching, a 3-inch coating of

broken local stone, of a similar coating Hartshill stone, gravelling, rolling, &c., varies from 3*s.* to 3*s.* 3*d.* per superficial yard.

For the paved roads the following are generally used :—

Stony Stanton, 4-inch by 4-inch setts, the cost of which, laid, but exclusive of concrete foundation, is	7*s.* 0*d.*	per yard super.
Rowley, 4-inch by 4-inch setts	6*s.* 6*d.*	,,
Ditto, 4-inch by 5-inch setts	6*s.* 9*d.*	,,
Wycombe, 4-inch by 4-inch setts	5*s.* 6*d.*	,,
Stony Stanton randoms	4*s.* 9*d.*	,,
Cement concrete foundation, 4½ inches thick, costs (laid)..	2*s.* 3*d.*	,,

For foot pavements :—

2½-inch York flagging, which costs (laid)	7*s.* 0*d.*	per yard super.
2½-inch concrete slab paving	3*s.* 0*d.*	,,
2-inch blue brick paving	3*s.* 0*d.*	,,
3-inch tar paving	1*s.* 6*d.*	,,

The principal works I have carried out in Oxford have been the main drainage and the widening of Magdalen Bridge, the latter work being still incomplete. At a meeting here of the Home and Midland Sections of the Association, on the 18th of February, 1876, I gave an account of the drainage works then in progress, which did not include the pumping station, rising main, and irrigation works. Before proceeding to describe these last-named works, I wish to add a few facts to, and make certain corrections in, the paper of 1876—

1. It may be interesting to state that the mode of sewer construction therein described has proved very successful in excluding the subsoil water from the 12 or 13 miles of sewers laid in water-logged soil. The main sewers are practically watertight under all conditions, but in times of high flood a large quantity of water gets in through the old house drains connected with the sewers in the low-lying parts of the city.

2. On account of the rapid growth within the district, and the connection of places outside it, the length of main sewers and surface drains in the system was eventually 45 miles, instead of 32¾ miles, as stated in 1876.

3. By reason of the reduction of "waste" effected by the water-works management, the dry weather flow of sewage was reduced from 2 millions to about 1¼ million gallons per diem.

4. The quantity of land purchased by the Board was in the

end 369 acres, instead of 320 acres, as stated in the paper in question.

The site of the pumping station is one recommended in 1872 by Mr. Bailey Denton, who, it was agreed, should be called in to settle this special point, which had been long in dispute, and which was "blocking" the progress of the whole scheme.

The buildings comprise engine and boiler houses, coal shed, two dwelling houses, smithy, stable and coach house, and stores. The pumping power consists of two single-cylinder beam engines, working independently of each other, and four Cornish boilers. The cylinders are 30 and 3-16ths inches in diameter and 6 feet stroke, and are fitted with Mather and Platt's patent pistons. The beams, which are cast in halves, are 24 feet 4½ inches long between extreme centres, 48 inches deep in the centre, and weigh 13½ tons each. Each beam is fitted with a pendulum counter. The fly-wheels are 18 feet diameter, and weigh 14 tons each. The main pumps are double-acting "bucket and ram" pumps. The buckets and rams are respectively 38 inches and 27 inches in diameter. The pump stroke is 3 feet, and the quantity lifted by each complete "up and down" stroke is 150 gallons. The buckets and suction valves are "Thomson and Porter's." The boilers are cylindrical, 6 feet in diameter and 24 feet long. Each has one internal tube, 3 feet in diameter, stiffened with "Galloway" conical pipes. Each boiler has two 2-inch safety valves, one of which would also blow off at low water, and there is a 6-inch safety valve on the steam chest, common to all the boilers, and weighted to blow off at 37½ lb. per square inch. A donkey-engine is fixed in the boiler house, for filling boilers or cold-water cisterns, independently of the main engines. The feed-water is taken from the river, which is at a distance of 150 yards from the engine house, and the waste from the cold cisterns returns to the river. The engines are usually worked at 14 strokes per minute. One engine running at this speed gives off, on an average of the day's work, 55½ indicated horse-power, which may be thus apportioned (if the gauge readings can be depended upon)—

Due to actual lift of 2100 gallons 54 feet high per minute	34⅜ H.P.
Due to friction of machinery	6½ H.P.
Due to friction in rising main	14⅛ H.P.
Total	55½ H.P.

When both engines are running each gives off an average of 63½ I.H.P., which according to the readings would be thus divided:—

Actual lift, as above	34⅜ H.P.
Friction of machinery	8⅛ H.P.
Friction in rising main	21 H.P.
	63½ H.P.

It will be found that the figures given for friction in rising main are much in excess of those that would be obtained by calculating the theoretical "loss of head due to friction." This may perhaps be partly accounted for by partial silting up of the main in the low places, but even after making ample allowance for this and other causes of difference, there remains enough discrepancy to show that for practical purposes it is not safe to put implicit trust in formulæ. In dry weather one engine pumps out the sewage in ten or eleven hours, including occasional stoppages, but on the other hand, in wet weather, when the flood is out, both engines have to work continuously to keep the sewage down. These fluctuations being so great, it is difficult to give reliable information as to the "duty" performed by the engines on an average, but when working under favourable conditions the "duty" is as under:—

One engine working singly—74,000,000 foot-pounds per cwt. of Welsh coal.
Each engine when working together—64,000,000 foot-pounds per cwt. of Welsh coal.

The foundations of the engine house and chimney shaft gave some trouble on account of the subsoil water and the instability of the ground, which consisted largely of running sand. The cutting was rather interesting from a geological point of view, as some distance from the surface it exposed what appeared to be two beds of river silt, with peat and soft clay intervening. The Oxford Clay was ultimately reached, and was found to be dipping rapidly. It was stepped out to an average depth of 32 feet below the present engine-house floor, and the whole area was covered with cement concrete of 5½ feet average thickness, before beginning the brickwork. The temporary pumping of the subsoil water withdrew so much silt and sand that settlements occurred at some distance from the buildings, the river walls were cracked in several places, and other damage done. The chimney shaft is 96 feet high from the raised ground level to the top of railing. It stands upon a cement

concrete foundation of pyramidal shape, 20 feet square at base. The shaft batters at the rate of 1 in 192, and the brickwork diminishes in thickness from 3 feet 4½ inches at bottom to 1 foot 1½ inch at top. The brickwork in the engine house up to floor level is in cement, and the whole of the other brickwork is in lias mortar. About 13,000 cubic yards of earth, mostly dredged from the river, were used to raise the site above flood level. In the design of the pumping engines and buildings only I had the advantage of being associated with Mr. T. Hawksley, P. Pres. Inst. C.E., but the execution of the work was in my own hands.

The rising main is 24 inches in diameter, and 2570 yards in length. Stone's automatic air-valves are fixed at the intermediate summits, and provision is made for emptying the main in sections by sluice valves and 4-inch branches at the bottom of each depression.

Of 369 acres of land purchased by the Board, 330 acres constitute the actual sewage farm, the whole of the land on the north side of the railway, and a small portion in the extreme south-east corner (see plan) being cultivated as an ordinary farm. Of the sewage farm proper 64 acres are permanent pasture, 226 acres arable, 28 acres are filter beds, and 12 acres are taken up by homesteads, roads, streams, reservoir works, &c. The farm is situate geologically upon the Calcareous Grit, Coralline Oolite, and Kimmeridge Clay. About two-thirds of the land is light and sandy, but in the low grounds, near the streams, a deposit of peat overlies the sand. The remaining third is stiff in character, varying from marl to a dense clay, about 45 acres of this being, in my opinion, altogether unfit for sewage utilisation. The land was so water-logged that the whole had to be underdrained, the drains being laid from 3 feet to 6 feet deep, 22 feet to 66 feet apart, and from 2 inches to 15 inches in diameter. At the outlets of the main drains into the streams the pipes were carried through walls of concrete, and they were protected against the entrance of rats, &c., by galvanised back flaps. The filter beds were specially drained to a depth of 7 or 8 feet by drains 33 feet apart. In these and in a few of the deeper drain trenches in other parts of the farm a good deal of rock had to be excavated. The average cost of the land drainage, as described, was nearly 9*l*. per acre. For the more complete drainage of the subsoil, and also to economise land, the various streams—which were very circuitous and shallow—were straightened and deepened, and in a few cases their water was

diverted through pipes from one point to another. It is estimated that the subsoil, drainage, and other works above mentioned, the filling in of ditches, grubbing of fences, &c., reclaimed to cultivation from 25 to 30 acres of waste land. The cuttings disclosed several Roman kilns and a quantity of pottery, and in the peat were found shells, and bones of deer, pig, cow, horse, and dog. Near the dwelling house, which it is said was once a monastic institution of some kind, were found human skeletons. These were, of course, of much more recent date than the relics beforementioned, and lay in uncomfortable proximity to the domestic well. About 5½ miles of new roads were made and the existing roads metalled, and the streams were bridged in many places to improve the communication between what had before been separate holdings. The roads were made with stone quarried on the farm, and cost about 300*l.* per mile. The surface of the land being very irregular (see contour map) no attempt was made—except in the case of the filter beds, hereafter described—to bring it to the smoothness you have seen on many farms. Still a great deal of money was spent even in reducing the greater irregularities, so as to enable the earth-distributing carriers to follow a fairly direct course. The ground for the filter beds was levelled at considerable cost, a good deal of rock having to be taken out in places. The beds marked A B C D and E on the plan exhibited were laid out to a fall of about 1 in 600 in the direction of the main carriers, and about 1 in 1000 in the direction of the furrows. As, however, sufficient land could not be found in one place level enough to lay out in this manner the full area of filter beds considered necessary, without an expenditure I did not feel justified in recommending, I devised a plan for the beds marked on plan F G H and I, which, as far as I am aware, had not before been adopted. The surface, which was on a quick slope, was only so far modified as to allow of the furrows being formed pretty regularly at about right angles to the slope, and for the proper gradient to be given them. The main carriers were laid nearly level on embankments down the line of slope, the side slopes of the embankments being about 1 in 5, and well turfed. The sewage being admitted into the carrier, and regulated therein by sheet-iron stops, according to the quantity being used, is made to flow in a thin stream over the sides of the carrier along its whole length. The sewage trickles down the side slopes, and thence enters and flows along the furrows, as required. It was difficult at first to prevent it over-

flowing from furrow to furrow down the slope of the bed, and thus washing the earth away, but a short experience enabled those in charge to control it. On the beds marked H and I, where the natural slope is exceptionally quick, these embanked carriers are divided into two sections, connected by a vertical fall down a concrete shaft. The sewage is brought to the filter beds and to a meadow adjoining them from the tank into which the rising main discharges, by 12-inch iron pipes, which have a fall enabling them to carry the sewage pumped by one engine. The velocity is checked by passing the sewage over a small concrete weir before admitting it to the carriers. These carriers are open, and are formed of concrete slabs, fitted together, and held in position by notched flat iron bars. (See detailed drawing.) The carriers (except those on embankments before mentioned) are divided into section, and the flow of sewage is regulated by wooden sluices, working in fixed frames. The overflow into the furrows is through rectangular openings in the sides, furnished with small wooden stops working in grooves in the concrete. The sewage is syphoned under the roads to the beds on other side by stoneware pipes surrounded with concrete, and leading into small concrete shafts, from which it is worked by wooden stops. The sewage for the other parts of the farm passes from the tank before mentioned for a short distance along a concrete carrier on embankment, from the end of which a cast-iron main, partly of 18-inch and partly of 15-inch pipes, makes a half circuit of the farm. From this main there are short branches of 15 inches, 12 inches, and 9 inches, worked by sluice valves. From the iron pipes the sewage passes into stoneware pipes jointed with cement, and laid about 2 feet 6 inches deep. On these lines of pipe are brick shafts, with grooves for sheet-iron stops, and overflow notches, also with grooves and sheet-iron stops. At all junctions of two or more lines of pipe, and at other points where an absolutely watertight stop is needed, galvanised iron tide-flaps with ground faces are substituted for the sheet-iron sluices. The sewage overflows from the brick shafts into shallow surface cuts, from which it is distributed on the land. The stoneware pipes are of course under some pressure when working, and there was at first some trouble from leaky joints, but these were not numerous and were easily stopped. One line of 15-inch and 12-inch stoneware pipes syphons across a depression in the land for a length of 500 yards; the head on the lowest part, when in full work, being between 5 and 6 feet. In this case a

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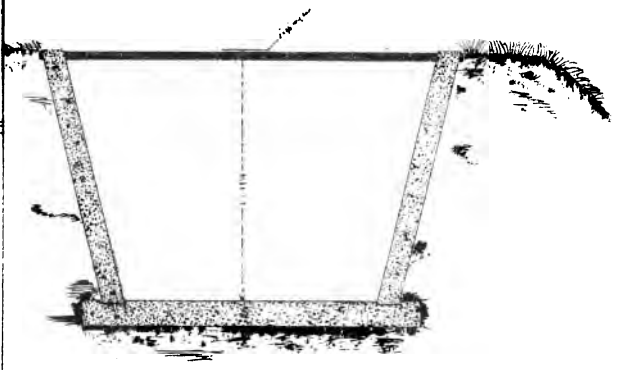

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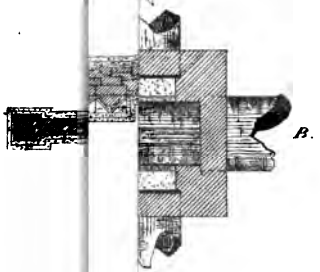
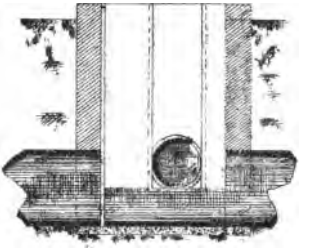
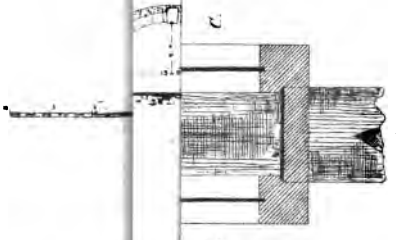




Section B.B.



Plan.
(Section Chamber)
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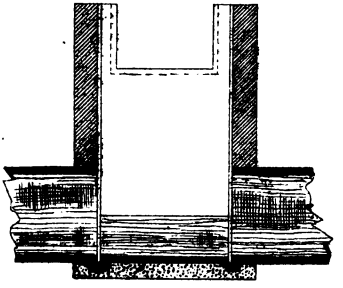

Section. D.D.

collar of cement-concrete was placed round the joints exposed to the greatest pressure. There are two other syphons of stoneware pipes, with Stanford's joints, one having a dip of about 9 feet. Each line of iron and stoneware pipes is so placed and graded, that it can completely empty itself on the surface of the land, so that no sludge can settle in the pipes when not in use. From the pumping returns of the two years ending 1st June, 1883, I find that the quantity of sewage and surface water delivered upon the farm has been 522,265,575 gallons per annum, or a daily average of 1,430,865 gallons. The area of surface actually receiving sewage is about 315 acres. Thus the yearly quantity per acre would be 1,657,986 gallons. The above is equivalent to a rainfall of 73·2 inches per annum. The natural rainfall during the same period has averaged thirty inches per annum, which is considerably in excess of the average over a number of years. In connection with the farm, an unusual expenditure of over 2000*l.* had to be incurred to meet the requirements of the County Lunatic Asylum, which took its drinking water from the stream below the farm. Dams were put in, and a reservoir to hold 300,000 gallons was constructed at a point above all chance of sewage pollution. A 4-inch cast-iron main was laid from it to the reservoir within the asylum grounds, a distance of 1570 yards. It was stipulated that 50,000 gallons per diem should be supplied, and the works are calculated to afford nearly 70,000 gallons per diem if required. The cost of the foregoing works has been approximately as under:—

	£
Purchase of site of pumping station, compensations, engines and buildings, embanking, &c.	19,125
Rising main	7,350
Farm—	
Purchase of 369 acres of land, compensation, laying out for irrigation, water supply to the asylum, repairs, alterations, and additions to farm buildings, working and maintenance, up to the time of commencing a separate farm account	53,395
Legal and other charges, cost of evidence, &c., at inquiries, cost of loans, and establishment expenses ..	3,775
Total	£83,645

The annual cost of pumping the sewage is about 1000*l.* The financial result of the sewage farming down to Michaelmas last was that the receipts had exceeded the expenditure by 545*l.* It

will of course be understood that neither the cost of pumping, nor the interest and repayments on account of loans for purchase of land and works are charged against the farm; but, on the other hand, one-twentieth of the loan of 4000*l.* obtained for stocking the farm, together with interest at 4 per cent. on the amount remaining outstanding, has been paid off each year out of farm account. An outbreak of foot-and-mouth disease among the cattle in 1881 occasioned a loss of 300*l.* or 400*l.* It should also be mentioned that the land came into the hands of the Board in such an exceptionally foul condition that a considerable area could not be cropped until last year, and the expenditure in cleansing the land has necessarily been very great. I venture to think that but for these untoward circumstances, and the generally depressed state of agriculture, a better result might have been shown.

Magdalen Bridge, 164 yards in length, crosses the two branches of the river Cherwell and a meadow between them. It is the only means of communication between the City of Oxford and the eastern suburbs, containing about 9000 inhabitants, and it also leads to the two main roads to London. The bridge, the erection of which dates 110 years back, is a stone structure of elaborate elevation. It has six semicircular river arches, four semicircular and one three-centered land arch. The bridge is narrow in proportion to its length, the carriage-way being 18 feet and the footways respectively 4 feet 9 inches and 3 feet 9 inches wide. It has of late years been notoriously insufficient for the traffic, and the local board has long contemplated widening it. There were also fears of its stability, owing to settlements which had cracked and bulged the masonry, and as far back as 1878 it was thought prudent to stop the cracks with cement concrete, and to put in cramps and tie-rods. The advent of tramways a year or two back caused the Board to decide upon widening the bridge without further delay, and the Tramway Company was "persuaded" to contribute 2000*l.* towards the work, on account of the further hindrance of traffic, which it was seen would be caused by a double line of tramway being worked on the existing 18-foot carriage-way. It will, perhaps, be in the recollection of some of the Members present what a storm of indignation was aroused by the proposal to interfere with the bridge. Articles appeared in the London papers, meetings were held, and influentially signed petitions sent in, all with one accord protesting against what they were pleased to call "the destruction of an ancient monument," and asserting that the bridge was wide

enough for all requirements; but the Board, with pardonable obstinacy, persisted in thinking that those on the spot were the best judges of the necessity of the work. It was accordingly begun in April 1882, and is now well on its way to completion; and I trust it will ultimately be admitted by the objectors that, so far from an act of vandalism having been perpetrated, a work of much public utility has been done without detracting from the picturesque character of the bridge and its surroundings. The extension is on the south-west side, and is 20 feet in width. By this addition the bridge will have a 32 feet 6 inches carriage-way and two 7-foot footways. The tramway lines will be removed to the centre of the widened road. The elevation of the new part will be a reproduction of the old elevation. The preliminary borings having shown the presence of running sand under nearly the whole of the site, it was determined to pile down to the Oxford Clay, which is at a depth of about 18 feet below the surface of the meadow. The bearing piles are of English elm, with cast-iron shoes, secured by strong wrought-iron straps. The piles under the river abutments are 11 inches square and 14 feet long, and under the land abutments and walls 9 inches square and 18 feet long. They were driven by a Lacour's steam pile-driver, and penetrate 2 or 3 feet into the clay. The piles, 380 in all, are placed about 4 feet apart from centre to centre, and the weight they sustain averages about 12½ tons per pile, or 400 lb. per square inch of section. The cost of the piles, including shoes, rings, driving, and cutting off level, was—11-inch, 43*s.* each; 9-inch, 38*s.* 6*d.* Elm sleepers, 6 inches thick, were spiked down to heads of piles. One set of river foundations was completed at one time. Dams were in each case thrown entirely across above and below the bridge, and a temporary cut was made from one branch of the river to the other, to facilitate the passage of the water. Four pier and abutment foundations were thus in hand at once. Each one was surrounded with 9-inch by 13-inch elm sheet piling, 9 feet long, shod, and driven as before described. The cost of the sheet piles, driven and cut off, was 10*s.* 6*d.* each. The ground was excavated one foot below the heads of the bearing piles, and the spaces were filled in with cement concrete, which was carried up to the level of the top of the sleepers, at which height the masonry commenced. The piers and abutments were faced 18 inches thick and bonded with "through" courses in Stanworth stone (a mill-stone grit, quarried near Blackburn), set in cement, the filling

being of cement concrete. The course from which the arches spring is 2 feet high, and is formed of single stones going through the whole thickness of the piers. The old foundations were discovered to be two thicknesses of 6-inch elm planking, laid a little below the river bed, without any bearing piles. These foundations had settled so irregularly that the piers and abutments were much out of level. As the Thames Valley Drainage Commissioners intend shortly to deepen the river considerably below the old foundations, it was thought advisable to take this opportunity of securing them. Skewbacks were cut under the old work, and inverted arches of 18-inch brickwork in cement, with a versed sine of 3 feet 6 inches, were put in from pier to pier. The river bed between the new piers was also covered with a foot of cement concrete, in order to prevent the heads of the piles being exposed if the river bed should be scoured out at this point after its level has been permanently lowered, and the work was finished by a sheeting of 3-inch elm piles driven across the river above and below the bridge, and tied into the brickwork and concrete. This work was, in the south-east branch of the river, made difficult and risky by the great pressure of water outside the dam (increased by high floods). Springs kept boiling up at all points, and had to be constantly watched and dealt with, as they caused movements of the sand. The work was pushed on night and day, and was finished without mishap, except the slightest possible settlement of one abutment. Under the abutments of the land arches and side walls the foundation is of lias concrete from a foot below to 2 feet above heads of piles. The ashlar in the side walls and pillars is of oolitic limestone from the Taynton quarries in this county. The land abutments and arch-voussoirs are partly of Taynton and partly of Stanworth stone. The backing of the walls is of a tough limestone from a quarry on the sewage farm in the Coralline Oolite formation, and the abutment backing is of concrete. The whole of this masonry is set in lias mortar. A straight joint is made between the new and the old work, and the only ties are wrought-iron "lewis" bolts, "lewised" into the old arch stones and turned down and cemented into the new ones. The parapets are of Taynton stone set in cement, and the several members are secured together vertically by slate "dowels," and horizontally by cement "joggles," no metal ties or cramps being used. The arch spandrils are filled with lias concrete, and a ring of that material is carried round the large arches. It has been found necessary to

cut away a large quantity of the old masonry and put in new stone, some of the old arch stones in particular having perished to a dangerous extent. It is intended to pitch the carriage-way with 5-inch setts on 4½ inches of cement concrete, and the footways will be of 2½-inch York flagging, with 12-inch by 6-inch kerb of Stanworth stone. A travelling 5-ton steam crane has been constantly at work taking away the excavated soil, depositing the filling, drawing piles, and conveying from point to point all materials and appliances required. The works have therefore made rapid progress, with a minimum of hand labour. The contractor is Mr. George Moss, of Liverpool, to whom great credit is due for promptitude and skill. The cost of the work, including the underpinning of the old bridge (paid for by the Thames Valley Drainage Commissioners), but exclusive of land purchases, compensations, and establishment expenses, will be about 10,600*l*.

The Oxford Tramways consist of two lines of 4-feet gauge, the one running from the Great Western Railway approach, through the city, over Magdalen Bridge, to the eastern extremity of the district, and the other from Carfax (the centre of the city) to the northern limit of the district on the Banbury road. The two lines are connected at Carfax, but are not worked together. A Provisional Order has been recently obtained for a third line, of nearly a mile in length, along Walton Street, which is nearly parallel to the northern line already made. The system is for the most part a single line with passing places, but over the narrow bridges, where there is not room for a single line in the centre of the road, double lines are laid. The engineers of the Tramway Company are Messrs. John Brunton and T. Claxton Fidler, MM. Inst. C.E., 13A, Great George Street, Westminster, and the contractor is Mr. E. D. Mathews, Assoc. M. Inst. C.E., Union Court, Old Broad Street, E.C. The permanent way is of a simple and somewhat novel character, and was specially designed by the engineers. The rails are steel, of bridge section, weighing 67 lb. per yard, and have a continuous bearing upon a cement concrete foundation 4½ inches thick. The rail ends are held by cast-iron shoes, 9 inches in length, weighing about 23 lb. each, and are kept to gauge by a flat wrought-iron tie, 2 inches by ⅝ inch, the ends of which are turned up so as to go into holes in the bottom of the shoes. On the upper side of the shoe there is a projecting rib 6 inches long and ¾ inch deep, which fits accurately into the hollow of the rail, and along the outer edge of the shoe

there is a lip, under which the outer flange of the rail fits. A wrought-iron cover plate 2 inches wide, is placed over the inner flange, and clamped down through the shoe by three $\frac{5}{8}$-inch bolts, the middle one also passing through the gauge tie. Thus the whole is fitted and fastened effectually without timber or iron sleepers or fish plates. It is claimed that this mode of construction admits of alterations or repairs with a minimum of disturbance of the permanent way. The space between and 18 inches outside the rails is paved with 5-inch setts upon $4\frac{1}{2}$ inches of concrete, except that on each side of the rail a course of wood paving, $2\frac{1}{2}$ inches wide, is bedded direct on the flanges. The points and crossings are of chilled cast-iron, and the curved rails were bent cold at the works to proper templates. The lines have hitherto preserved their position and level accurately, and I believe the system to be a very good one. The average cost per mile of single line was 3627*l*.

As you will have an opportunity of visiting the works I have herein described, I trust a useful discussion upon them will ensue. Although I have almost to apologise for having so few works of an engineering character to show you, I still hope that you will at least carry away from this Annual Meeting pleasant recollections of the numerous objects of interest and beauty in Oxford.

DISCUSSION.

Mr. ANGELL: The President asks for criticism. I have no criticism to offer: all I have to say are words of praise. I saw these works some years ago, when they were in progress, and I have seen them now completed. I believe they are most efficient works, designed with great skill and most efficiently carried out. I feel perfectly certain that Mr. White's services are appreciated in Oxford. Oxford may consider itself very fortunate that, in comparatively so small a town, they have secured the services of so good a man. I am certain his services are appreciated; I hope they are also adequately rewarded.

The PRESIDENT: This is very kindly criticism, I must say.

Mr. C. JONES: Most of us, I am sure, will be disposed to deal with any criticism in the spirit that Mr. Angell has exhibited. Our President has not given us many debateable points. He has left no peg on which we can hang criticism, except to repeat how pleased we have been with everything we have seen. There is

one point to which our attention was particularly directed to-day, and that is the splendid way in which the works are kept. That is not a matter to criticise, but rather to commend. I know it is natural for people to say, "What is the use of spending money in this way? What is the good of having parks nicely gravelled, and grounds tastefully laid out?" Well, I say it is a good investment of money. Where works are kept with care and skill, it influences the working of the whole system: the men employed dare not do their ordinary work in a slovenly way; but if the works are kept in an unsatisfactory manner, everything else is generally unsatisfactory also. I was therefore exceedingly pleased to see the very creditable way in which the works are kept at Oxford.

Mr. J. GORDON: At this late hour, especially as I am one of those who detained you rather long this afternoon, I shall only say a word or two. I can add my testimony to that of the gentlemen who have spoken, and honestly bestow the very highest praise on everything we have seen. Everything seems to have been carried out in the best and most substantial manner that could be devised. Although I was not present at a former meeting, when the President read a paper respecting the sewers, I believe they have been carried out in an efficient and proper manner—quite equal to the other works that we have seen to-day. I know that his paper on that occasion interested me very much when I read it; and I see before me now the section of a sewer, carried out under difficult circumstances and made completely watertight, although apparently in a somewhat expensive way. I am sure it is in the interest of public economy in the end to carry out works in this substantial manner, notwithstanding that some members of corporations and local boards may think sometimes that money is being expended which might be saved. I for one am of opinion that Mr. White has carried out these works in such a way that every Member of the Corporation must be as proud of them as we are that we have a President who can carry out such works. They are really a credit to any engineer in the country, and they are works which might be pointed to as worthy to be copied under similar circumstances. I adopted the particular mode of construction to which I have alluded, when I had to deal with a sewer under similar circumstances, and I found it a great advantage to me to be able to say that a similar work had been carried out at Oxford. The work I allude to has been carried out under my direction in a successful manner at Ludwigshafen on the Rhine, and I am very much

obliged personally to Mr. White for having given that paper to the Association in which he described and illustrated the construction of sewers. I am sure the previous speakers have only expressed the feelings of us all, that we are delighted with what we have seen at Oxford.

Mr. PLATT: I would just suggest that it would be a very good thing if some of these diagrams, relating to the drainage and other works, were reduced and printed with the proceedings of the Association.

Mr. JERRAM: The only thing open to criticism is the work not done by the President. We are all exceedingly pleased with the way the works of which he has charge are executed, and especially with the skill shown in their design and construction. There is one thing, however, which struck me at the pumping station—is there any one appointed to look after any pollution of the river? because I saw—and indeed you said—that at times you did have an overflow of the sewage. I have been looking at the tramways rather narrowly, and I cannot say, from what I have seen, that they are a success. The idea of their construction is certainly a novel one, but I do not think it will be copied anywhere else. Your street traffic is light—you do not have heavy lorries or heavy wagons, and the state of the tramways shows that they are not suitable for heavy traffic or for steam power.

Mr. LEMON: I think one thing, gentlemen, should not be lost sight of in connection with these works—that they have been carried out as near as possible for the estimates given by our President. I think it is most creditable that he has been able to carry out such important works for the amount of his estimate. Ratepayers often say, respecting such undertakings, "they will cost about double the estimate," but that certainly does not apply in this case. Respecting the works themselves, I can only speak in terms of the highest praise. I never saw better works, and I must say admirably maintained. The man who has charge of the engines certainly deserves great praise. I cannot speak in terms of such high approval of the farm. I know that the President has nothing to do with it, and that it is in the hands of a farm committee. The farm, I think, is undermanned, and very inefficiently managed. I hope the farm committee, in their own interests, will take measures to produce better results from the farm than they now seem to do.

Mr. PRITCHARD: I cannot allow this opportunity to pass with-

out also adding my testimony to the excellent character of the various works which have been carried out in Oxford by our president. Some seven and a half years since I had the pleasure of seeing the work of sewer construction when in progress. We then had an opportunity of inspecting some of the most difficult portions of the work. That under the old castle tower was a masterpiece of engineering skill, and the syphon under the Cherwell was admirably planned and carried out. To-day we have seen the consummation of the work at the pumping station. Well, from the sewers to the pumping station, I have not the slightest hesitation in saying, that I do not think there is a town in this country which has its sewers and sewerage works so well designed, so excellently constructed, or so noble looking, so valuable, and so good in every particular—sewers, engines, and pumping plant. The whole of the undertaking, from the sewering of the town to the pumping station and the machinery, is simply one grand success. I am sorry that, like Mr. Lemon, I cannot say so much about the farm: perhaps it is too soon, just at present, to speak positively about it. Many of us used to think there was an El Dorado in sewage, and for a time we believed considerable sums could be realised from it. But that is all gone. I have had experience of sewage farms, some under my own direct management and of some as consulting engineer, and I honestly say this—that I never saw a sewage farm so efficiently managed whenever a local board, a corporation, or a committee of either body had charge of it, as it would have been if placed in the hands of such men as Col. Jones, of Wrexham, Lord Warwick's manager at Leamington, or various other gentlemen whom I could name as successful sewage-farm managers. But so far as the engine works at Oxford are concerned, there can only be one opinion, and that is, that they have been well designed, and well constructed. Mr. Angell has alluded to a most important point, and that was as to the due appreciation of the services of the engineer. I am not curious, and I do not make any inquiries as to what Mr. White is paid; but if any engineer had been called in—any Westminster man—to execute these works, they could not have been better done, and there would have been some thousands of pounds paid in commission. I therefore hope and trust the Council of Oxford have not forgotten that portion of their duty. I repeat, I am not inquisitive on the point, and I am not making inquiries. I sincerely thank our President for the opportunity we have had

of seeing these works, and even for those who have had considerable experience there has been something to learn: we have seen something which appears to be novel, and something certainly unique. I do not think that any of us has constructed nobler engines and pumping stations than those inspected to-day.

Mr. JAMES HALL: I may perhaps take it upon myself, as representing the extreme north of England, just to thank you, Mr. President, and to congratulate you upon the work you have shown us to-day. I should just like to know for my own information —and possibly it may be useful information for others—whether, when you designed these works, you took into consideration if it would be desirable to clarify the sewage by passing it through tanks, and utilising a certain portion of the solid matter in a dry state upon the land. It strikes me—though I do not set myself up as a great authority on the subject—that if the solid matter from the sewage had been collected in tanks, it might have been utilised in raising the level of the ground, which I understood from you rendered it necessary for hundreds of tons of foreign material to be brought to the spot. I ask for information, because I am preparing a scheme on a small scale, for a population of 12,000, of the Borough of Stockton. I certainly think that Mr. Pritchard is hard on local boards and corporations, when he says that they cannot manage sewage farms. Corporations and local boards may have failed, but I do not think that it is necessarily so in any case when properly constructed.

Mr. PRITCHARD: I speak from my own knowledge and experience.

Mr. JAMES HALL: I am speaking from my own knowledge too. I know a local board in the north of England—a very small local board—which has a sewage farm that does all that is necessary for the disposal of the sewage, and pays its way with a penny rate in aid. I think that is about as reasonable as you can expect. With respect to Mr. Jerram's remarks about the Oxford tramways, I should just like to make one suggestion. I think if the Corporation came to Stockton and saw the steam trams, they would find they were handicapped by not adopting steam. The gradients in the two towns are very similar, although we have some a little worse than any of those in Oxford, and it is found that steam trams are most economical. On humanitarian grounds, I regret the cruelty which must occur in working horse tramways, but which is entirely obviated by employing steam.

Mr. PARKER: The last speaker has gone into the financial aspect of the matter to some extent. I find that the total cost of the works has been 83,000*l.*, and that the annual cost of pumping is 1000*l.* Mr. Hall has spoken of a town in the north—I did not hear precisely where—which has a sewage farm that is being managed for a penny rate. That must be a very favourably circumstanced town indeed. The repayment of the principal and the interest on the capital expended on the Oxford works, at 3½ per cent., repayable in fifty years, would represent an annual outlay of 3280*l.* which the 1000*l.* for pumping would increase to 4280*l.* This at all events will have to be paid for the next fifty years. Then we come to the profit—or rather, I should say, the adverse balance—of the farm; because there is only 545*l.* to be placed to its credit. That only represents about 10*s.* an acre. A sewage farm is undoubtedly the best and most satisfactory method of dealing with the sewage of towns; and the effluent water we saw going into the river to-day showed most gratifying results had been obtained. I do not know what the rateable value of Oxford is, but I think it would be interesting to this meeting if the President stated what the cost of the sewage farm is in the pound. On the whole I congratulate you on the success of the sewage farm, and more particularly on the satisfactory character of the effluent water.

Colonel JONES: May I be permitted, as a visitor, to thank the President for the pleasure he has afforded us on our visit to Oxford? I agree entirely with Mr. Pritchard as to the excellence of these works, which I had the privilege of seeing during their construction. The pumping engine is a pleasure to look at, and it works admirably. I do not wish to criticise the sewage farm adversely, but I have already said in public that local boards and corporations do not generally succeed in the management of sewage farms. There are too many cooks, and you know that "too many cooks spoil the broth."

Dr. ACKLAND: Mr. President and Gentlemen—I am much obliged to you for giving to a visitor, who is only here by your permission, an opportunity of saying a very few words. First of all I would thank you, as an old resident in Oxford, for coming to this city, and I do so perhaps with somewhat deeper feeling than may be obvious, at all events, to the younger Members of your Association. I have been in Oxford quite long enough to have seen it first of all a model in a good many things of what unquestionably a thoroughly badly arranged place might be; and I think I could

show by quite certain evidence, not within the recollection of any Oxford resident but myself, by diagrams, and otherwise—for I have had drawings made of these eccentricities—that it was as bad as it possibly could be in sanitary matters, and for house-water supply and sewers, even in the hospital to which I was attached, for thirty years before the destruction of some of these things which it was my great privilege and happiness to have destroyed. I took carefully prepared drawings, to show how bad the sanitary arrangements of our wards could be, under the very eyes, as it were, of persons specially appointed by the country to see things otherwise. This is one thing I have seen in my working life; but I have to-day heard something else. I have heard gentlemen from various parts of England, Members of this Association, say that they have had much satisfaction in seeing the work done here in these directions as well as it can be done. I should have thought it extremely impertinent in me to have expressed in your presence any opinion on this point; but I thankfully echo the opinion which has been expressed from so many parts of the country by yourselves, and I am glad that I shall be able to quote the authority of this important meeting. Any observations which I might make on this subject would not possess that authority which it will have in your names. I will not venture to detain you, but there is one thing I thought would almost justify me in asking you to be allowed to say something. After the interesting observations I have heard to-day respecting Reading, I should have liked to have had permission to say a word, and I should not have contradicted the speakers who attacked the works there. I think it would not be right, in the presence of so many persons actively engaged in engineering operations, requiring the highest intelligence, and essentially a progressive department of engineering science, if I were not to point out to you that this is not a matter merely as regards Oxford, or a matter solely as regards Mr. White our engineer, but it has something to do with the opinion of the whole country. I will mention only two names, the one a colleague almost of my own, and the other had just taken his degreee before I came to Oxford as an undergraduate—Lord Salisbury and Mr. Gladstone. They were students here, and would carry away with them into the country and the Legislature their opinions concerning what was good for a hospital and good for a town, and it was no trifling matter that young men should be educated in this place with an altogether faulty and ignorant estimate of what was due to

the country in their conception of this subject. I therefore felt it to be something of a duty to address you, for the expression of your opinion will justify me in saying, when I send students here intended for the medical profession, Go to Mr. White, who will show you through these works, which will be a sort of standard for you. I assure you, when I first endeavoured to instruct myself on matters of this sort, more than thirty years ago, the only thing it was then in my power to show was what ought not to be done. This is useful in some respects; but it is far better and a much more pleasing task to be able to show, in the town where one lives, what can be done—to show one thing more: how by a quiet, modest, manly perseverance by one person, trusted by his fellow citizens, these things can be carried out, under great disadvantages. There is probably no person in this room—certainly not Mr. White—who knows of the sharp contests we used to have in this very room in 1848, the cholera year, to get any attention paid to this subject either by the authorities of the town or the University. Now, in the very same place, I hear you congratulate Mr. White and Oxford on the position in which it is now placed with respect to Sanitary matters, by your President. I regret I was not able to be present yesterday, but now I have great pleasure in thanking you for the words of encouragement you give to us all, through one of your brethren, and that his work, in endeavouring to create a healthy public opinion concerning Sanitation, meets with the approbation of that profession to which I believe you are all devoted. Such an Association as this, no one knows better than yourselves, was not so much as dreamed of twenty years ago. I therefore add my respectful testimony to the value of your labours, and my thanks as a resident of Oxford, for the approval that you have given to Mr. White's work.

The PRESIDENT: It seems a very strange thing to say, but I really should have been disappointed had there been no criticism at all. I am none the less grateful nevertheless to Mr. Angell and other Members of the Association, for the eulogy they have passed on my work. Still I feel there must necessarily be some parts which are more or less imperfect, and which, if I had to do them again, I should do differently. You have, however, been extremely merciful in your criticism, so far as you have gone. As regards the remark made by Mr. Jones, respecting the way in which the works are maintained, I should say that the greater part of the credit is due to the man on the spot—the engineer who has charge

of them, at the pumping station. He erected those engines for the company he then represented, and takes a pride in them, and keeps them as well as a man might be supposed to attend to his children. Mr. Gordon referred to the section of the outfall sewer and the peculiar mode of construction to resist the action of the subsoil water. I feel proud that a gentleman of Mr. Gordon's standing in our profession should have thought that system worth a trial, and also that he found it equally successful. Mr. Platt asked that some of the drawings might be reduced, and published in the Transactions of the Association. I shall be very glad to do anything in that way of which the Council and Secretary may approve, and I should be glad if, before he leaves, Mr. Platt will point out the drawings to which he refers. Mr. Platt also asked the cost of pumping per 1000 gallons one foot high. I stated in my paper the cost of pumping annually, but in making the calculation for the purpose of answering Mr. Platt's question, it is necessary to make a little deduction from the sum named, 1000*l*. That includes the wages of the man who regulates the valves on the farm, also coal supplied to the two houses, oil for lighting them, and some other similar items. But if everything be included which is fairly chargeable—fuel, lubricants, wages, repairs, fittings, &c.—the cost would work out to about ·4 of a penny for pumping to the full height. This should be taken at 54 feet, and then Mr. Platt's question is readily answered. The cost for pumping 1000 gallons one foot high would be the 54th part of ·4 of a penny.

Mr. JERRAM: What do you allow for friction in the mains?

The PRESIDENT: When one engine is working, the resistance due to friction in main is equal to 23 feet "loss of head," and when the two engines are working, the "loss of head" is 33 feet. This is nearly double the theoretical "loss of head." (With both engines running, the increased velocity puts on another 10 feet of resistance, and makes 33 feet "loss of head" due to friction.) Mr. Jerram asked, who looked after us at the sewage pumping station with regard to the action of the sewage overflow. I can only say we are looked after very sharply both there and on the sewage farm. There is a resident Inspector of the Thames Conservancy Board, who is also an engineer by profession, and therefore well qualified to look after this matter, and on the whole he is very well satisfied with our behaviour. It cannot be denied that, when a sudden storm comes down in the night, or even in the day, with only one engine going, there is a slight overflow,

but what does thus overflow I think comes up to the standard of purity of the Rivers Pollution Commissioners, being almost wholly rain water. Of course I am not concerned to defend the design of the tramway, but at the same time, in justice to the engineers, who are not present, and with whom I perhaps ought to have communicated, I may say I consider the point Mr. Jerram has alluded to does not indicate any radical error in that particular part of the permanent way, but is due simply to using one course of wood paving on either side of the rails. Mr. Jerram did not point to any sinking of the entire rail, but simply spoke of the wearing of the wood paving alongside the rails. That I am not surprised at. I knew from the first that the wood paving would not stand, and I believe it is contemplated by the engineer of the company to substitute some other material, I think scoriæ bricks: wood and granite side by side cannot possibly wear equally. Mr. Lemon complimented me on my adherence to the original estimates for the works. It so happens that I have been very much abused in Oxford for exceeding the estimates for the works; but I have never taken the trouble to defend myself. Since Mr. Lemon has raised the question, I am bound to say the works have been completed within about ten per cent. of the estimate, although many things were included which I did not know of in the first instance, and which it was consequently impossible to estimate for. The cost of the purchase of land, compensation and legal expenses, I expressly left out of my estimate; and as you will have seen, from the figures given in my paper, these came to a considerable sum. On the whole Mr. Lemon's remark is perfectly fair.

Mr. LEMON: I remember you were told, by some obnoxious ratepayers, when you designed the works, that they would cost double your estimate.

The PRESIDENT: The actual cost of the works estimated for was about 102,000*l.*, and the estimate was something over 90,000*l.* Of course, there were some alterations and additions made by the Board, after the estimate was prepared. With regard to the condition of the sewage farm, I certainly do not hold it up as a model sewage farm, by any means. I devoted a good deal of time and thought to the laying out of the land and distribution of the sewage, and these arrangements, I think, work fairly well. But with regard to the condition of the land, I do not feel particularly proud respecting it: I think the farm committee themselves feel that the land might be in much better condition. It is

very natural, of course, that they should wish to keep down the expenses of labour. So far as a committee can manage a farm, they no doubt have managed it very well; but that a little more labour on the filter beds would be very advantageously expended. Mr. Pritchard hits out very hard indeed at local boards managing sewage farms. Probably he is right in the main, but I can only say that the local board of Oxford would have been delighted to let their sewage farm at a very moderate rent, and they would do so now, if they could only get a reasonable figure. The most simple way for everybody would be to let sewage farms, but I fear that many other local boards are in the same position, and cannot find tenants. As to the compensation given to me, I certainly have not had 5 per cent. on the outlay. I have been paid my salary; more than that I cannot say. However, I do not wish to refer to that any more. Mr. Hall suggested depositing tanks, and that the disposal of the sewage sludge on the land might have been an advantage. I did think of doing something of the kind, but I was led to start the farm without doing it, and up to the present time I have not seen any real reason to incur the expense and the nuisance of having to deal with the sludge. The only fault of dealing with the raw sewage is, that when a filter bed has been working continuously several days, a thin crust forms on it, which, however, dries rapidly and disperses, and in a few days after the sewage has been off, disappears entirely; therefore up to the present time I have not felt the necessity of depositing tanks. I am not sure I understood Mr. Hall's remark about using the deposit to raise the level of the ground.

Mr. JAMES HALL: I understood you had to bring more soil to raise the level of the surface of one portion of the ground.

The PRESIDENT: Yes, 13,000 cubic yards of earth have been deposited at the pumping station. Part came from the foundations of the engine-house and other buildings, but the great bulk was dredged from the river close by, and I could not possibly have got it cheaper than that. I do not know that I differ much from Mr. Hall as to steam power for traction on tramways; but I fear any attempt to introduce steam power into Oxford would be looked upon even as a greater offence than the widening of Magdalen bridge, if that were possible. More than that I cannot say. It would be such a violation of the peaceful and classical associations of Oxford, that the man who was bold enough to suggest such a thing would get very short grace. Mr. Parker went into the financial

question rather deeper than I was able to follow him. I am afraid I cannot give him the information he wants. We have no borough accountant, but the accounts are kept partly by the clerk, and partly by myself; it is therefore very difficult to give detailed information on any financial point raised suddenly. The effect of the whole scheme of drainage and irrigation works has been about a 1*s.* 1*d.* rate in the year. That covers everything. Reference was made by Mr. Parker and another speaker to a penny rate, but I understood him, a penny rate in aid of a sewage farm.

Mr. JAMES HALL: I said a penny rate in aid.

The PRESIDENT: We have no rate in aid, and we really saved 450*l.* in the first year, under very adverse circumstances, but which was lost in the second by an outbreak of foot and mouth disease. Agriculture has been very much depressed, and this land came to us in a very bad condition. It was known that it was coming to us and it was consequently neglected, and a portion of it could not be cropped the first year. I am sorry Dr. Acland has gone, because I think he was entitled to a word of thanks. I am sorry he was not able to be present last night. One of our honorary Members, Mr. John Thornhill Harrison, would have been present, had he not had a Government Enquiry fixed beforehand for to-day near to Newcastle. It will be gratifying to Members to know the interest taken in our Association by one of the Inspectors of the Local Government Board. I can only in conclusion thank you for your graceful criticism passed on my work, and for the courtesy and kindness exhibited to me generally.

THE SEPARATE SYSTEM OF SEWERAGE AS CARRIED OUT AT READING.

By ALBERT W. PARRY, Assoc. M. Inst. C.E., Borough Surveyor, Reading.

As many references have been made to the separate system of sewerage in Reading, I have endeavoured to put together, for the information of the Members of the Association, as much practical detail as I believe will fairly illustrate the system as it is or shortly will be in operation.

The system cannot be taken as a complete one so far as surface water is concerned, as all the sewers are not new. A system of sewers for the disposal and utilisation of sewage was completed about seven years ago, and the old sewers, which formerly conveyed both sewage and surface water, are now used only for surface water, and in streets where there were no such sewers, new ones are being laid.

The urgent need for keeping the rain water out of the main sewers has been experienced during heavy rains and floods, when surface water in large quantity found its way into the sewers, which so increased by dilution the quantity of sewage, that great inconvenience has been caused by the volume that had to be pumped and received on to the farm at a time when it was least wanted.

Reading certainly made a mistake in not dealing with and providing means for the completion of the double system of sewers in their Act obtained in 1870, which provided only for the disposal of the sewage, and not for the completion of the sewers for surface water, which has had to be undertaken under powers obtained by a special Act for general purposes in 1881. The consequence has been that the drainage of sewage from houses has been completed to a large extent without regard to the disposal of rain water, and the carrying out of powers obtained under the Reading Corporation Act, 1881, necessitated a second opening of streets where new surface-water sewers and branch drains were required, and some amount of irritation is caused to owners of properties who had, as they thought, completed their drainage, and who now have to make additional drains at a second expense.

The disposal and utilisation of sewage in Reading has already been described by me in a former paper, but for present convenience I will again briefly epitomise the system.

The works were designed by Messrs. Lawson and Mansergh, of Westminster, and were executed under their direction.

Reading is divided into three principal districts by the river Kennet and the ridge traversed by the Bath road. The districts are drained by separate main sewers, which discharge into a 6-foot barrel sewer.

The main receiving sewer has been constructed of a large size in order to act as a reservoir with the view to regulate the pumping.

Great precautions were taken to prevent leakage into the sewers, and for this purpose all the brick sewers were rendered and made water-tight.

Ordinary sewer pipes were used, and the joints, except in a few cases at the commencement of the work, were made with cement. Many of these pipe sewers are laid 3 or 4 feet under water, and in the Caversham road, in soft silty foundations.

The leakages that occurred before the commencement of the house drainage works, no doubt entered the sewers by means of the clay-stoppered junctions, and was estimated by the resident engineer to amount to about 3 gallons per head in the winter, and 2 gallons in the summer.

Duplicate engine power is provided at the pumping station, because during a part of the year the Thames floods render the water-pumping power useless.

There are two horizontal condensing engines with 24-inch cylinders and 3 feet 6 inches stroke, with three boilers 28 feet long and 7 feet in diameter. The engine pumps are 30 inches diameter and 3 feet stroke, and work at the rate of 14 strokes per minute. There are three turbines for ordinary pumping purposes. The turbine pumps are 18 inches diameter and 2 feet 6 inches stroke, which work 15½ strokes per minute.

To provide for the possible contingency of a breakdown, or a rupture in the rising main, an overflow into the river has been provided.

The sewage is pumped to a height of 46 feet, the rising main being 4711 feet long and 24 inches diameter. It then enters a culvert 3 feet in diameter, in which it flows by gravitation for a length of 8192 feet to the sewage farm.

The farm consists of 700 acres lying to the south-west of the

town, outside, but abutting upon, the boundary of the borough; and the subsoil is well suited for the purposes of irrigation. A large area of the middle meadow land has been always subject to floods, but by deepening the river Kennet between the Fobney and County locks 3 feet, the drainage has been considerably improved, and it is now only affected during unusually excessive floods. The lowering of the river has not only improved the drainage of the low lands purchased by the Corporation, but also the property of a neighbouring landowner who contributed to the cost of the work; and it has also made a valuable addition to the Waterworks' pumping power at Fobney Lock.

The land has been prepared with the view to its being divided into separate farms, only part of which will be irrigated. Ten acres have been prepared for continuous intermittent filtration, so that the sewage may be drained more rapidly away, and to be used when the sewage cannot be beneficially applied to other lands.

The land generally has been drained 4 feet to 4 feet 6 inches deep, the drains being 60 feet apart in gravelly subsoil, and 40 feet and 30 feet apart in loamy subsoil. Intermediate drains have been laid in part of the filtering area, which reduced the distance apart to 15 feet.

Farm No. 1 contains 138 acres, of which 87 acres have been prepared for irrigation.

Farm No. 2 contains 205 acres, of which 170 acres have been prepared and partly drained; in other parts of the farm 18 acres have been prepared and partly drained, and about 25 acres are in course of preparation.

The cost of the works has been as follows:—

	£	s.	d.	£	s.	d.
Main sewers	69,779	10	7			
Weirs, sluices, and buildings at pumping stations	14,700	0	0			
Engines and pumps	5,931	0	0			
Turbines and pumps	2,807	0	0			
Rising main	6,621	0	0			
3-feet barrel sewer and 18-inch pipe sewer to farm	4,901	3	4			
				104,739	13	11
Purchase of land for farm, and cost of works for preparing and laying out land for the utilisation of sewage				101,909	1	9
Deepening the river Kennet 3 feet				26,436	0	5
New buildings on farm No. 1	2,781	12	6			
Four cottages	720	0	0			
New buildings on farm No. 2, including three cottages	6,539	18	8			
				10,041	11	2
				£243,126	7	3

The house drainage works were commenced in November 1875, and proceeded rapidly, the owners of properties being evidently anxious to avail themselves of the new sewers and so avoid the recurring expense and inconvenience of emptying their cesspools.

Soon after the commencement of the works the question arose as to the wisdom of requiring every house to be drained separately, the owners of blocks of houses being desirous of connecting a number of houses by means of one junction with the main sewer. The reasonableness of this was apparent, to save the annoyance and expense of cutting through each house, and making so many branch drains across the streets to the main sewers. The difficulty that presented itself to the Corporation by their accepting this arrangement, was the responsibility that would fall upon them for the maintenance of what would otherwise be a private drain, so soon as a second house was connected with it, in consequence of the definition clause in the Public Health Act, 1875, as to sewers and drains; and to meet this difficulty, the Corporation framed an application form, and a series of regulations, which required that in cases where more than one house was connected to the main sewers by means of one junction, the length of drain from the junction in the main sewer to the back of the house, at which point a brick man-hole should be constructed, the drain and man-hole shall be constructed by the contractor under the Corporation, and the estimated cost of such work shall be deposited in advance with the Corporation. This, although the whole of the drainage work was done under the inspection of the Corporation, was to further ensure sound work, and means of inspecting the condition of the drain passing under the house, so long as any question remained as to the responsibility for future maintenance, which was satisfactorily settled afterwards in the Act of 1881.

The work of the Medical Officer of Health and Inspector of Nuisances, in dealing with cases in connection with premises having "defective, foul, and ill-constructed drains, closets, sinks, cesspools, &c., including premises having no sufficient drainage (nuisances injurious to health arising in consequence) and requiring to be drained into the sewers of the sanitary authority," before and after the new sewers were available for receiving sewage, was measured in accordance with the then existing circumstances.

I give below the number of cases of this description that have been dealt with, and also the death-rate during the last ten years, as taken from the annual reports of the Medical Officer of Health, which shows a remarkable amount of indifference on the part of

the death-rate to the measures taken by the Corporation to improve the town :

Year.	Death Rate per 1000.	Cases as stated above dealt with.
1873	17·7	114
1874	18·5	61
1875	18·3	136
1876	18·2	416
1877	17·2	401
1878	22·0	320
1879	19·2	376
1880	19·6	275
1881	14·1	192
1882	17·8	64

The progress made in carrying out the house drainage works is shown as follows :—

Year.	Number of Houses Connected.	Junctions with Main Sewers.
At the end of		
1876	1911	653
1877	3860	1236
1878	5212	1696
1879	5955	1956
1880	6696	2191
1881	7176	2357
1882	7654	2590

The number of houses in the town at the end of 1882 was about 8700, and the estimated population 43,466.

The average quantity of sewage pumped, as shown by our daily records, was, for the week ending June 15, 998,277 gallons per day, but on certain exceptional occasions, during continued heavy rain, the quantity has exceeded 2,000,000 gallons, in consequence, no doubt, of the drainage of surface water from the houses not having been undertaken and completed simultaneously with the drainage of sewage.

I should state that the hard rule excluding all surface water from the sewage sewers is relaxed in cases where there are small enclosed areas at the rear of houses, where a second grate or trap, if fixed for receiving rain water, would offer equal facilities for the emptying of slops.

The quantity of water supplied to the town and district is about

1,813,000 gallons per day, this being the consumption on Tuesday, the 19th inst., of which quantity

850,000	are for	domestic purposes.
165,000	„	railway companies.
160,000	„	trade purposes.
600,000	„	street watering.
23,000	„	flushing sewers.
15,000	„	public urinals.

The quantity used for domestic purposes has been tested in several districts—the water supplied to the railways, for trade, and for public urinals passes through meters, and the water used for streets and sewers has been carefully gauged. It will therefore be seen that out of the full quantity supplied, 888,000 gallons enter the sewage sewers, and the remainder, except what is taken away by the railway companies, goes into the surface-water sewers, the discrepancy between the figures showing the amount of the water supply passing into the sewage sewers, and the quantity of sewage that is pumped may be accounted for by the present imperfect surface drainage.

The 600,000 gallons shown to be as for street-watering purposes must be taken to include also the proportion for waste, which would amount to about 5 gallons per head of population supplied (about 50,000), and includes an area beyond the boundary of the borough. The street-watering apparatus in use would not take more than about 350,000 gallons per day.

Every sewer is flushed every fortnight, the greater part of them once a week, some districts twice, and others three times a week, acording to circumstances. Two men, and one horse, man, and water flushing cart, are regularly employed on this work, and in cleansing the brick sewers. During the first quarter of each day the two men assist at the pumping station in removing the scrapings from the screens in the sewage pits, and for the remainder of each day for one week they are flushing sewers by hose-pipe and by means of the flushing-cart down the sluiced manholes; in the second week of the fortnight there is less flushing done, and the remainder of their time is occupied in cleansing the ventilator chambers.

These same men also cleanse the brick sewers, and remove the silt therefrom at night, after the sewage is pumped out of the 6-foot sewer. The 6-foot sewer is thus cleansed once a week, and each of the three other brick mains are cleansed once in three weeks, one being done every week.

The sewage sewers are ventilated by means of open ventilators to the street surfaces, and in some instances, more particularly in crowded thoroughfares, where sewer gas has caused frequent inconvenience, an iron pipe has been carried from the ventilator to top of a high building, and the openings in the streets have been closed; and in a few other similar instances, where the houses stand back a long distance from the roads, iron standards 16 feet high have been fixed at the edge of the footpaths communicating with the ventilators. Again, in places where a high furnace chimney has been available, a connection has been made with it. One instance in which this plan has been found to be of special service, is the ventilation of the 6-foot sewer at the pumping station by connecting it with the chimney shaft by means of an 18-inch pipe, and keeping the chimney always aired by a little fire under one of the boilers.

The provision for carrying off the surface water has not been a difficult task so far as outfall is concerned, and there are very few towns so well situated in that respect. The river Thames skirts the entire northern boundary of the town, and the river Kennet runs through it. There are also the St. Giles' mill-stream—the Minster mill-stream having been abolished as a watercourse under the original main sewage scheme, a 15-inch pipe sewer was laid in its stead to receive the drains that discharged into it; the Holybrook, which is at a level of 7 feet above the river Kennet as it passes through the town and supplies water power to the Abbey mills; Gunter's brook, and other small streams, the existence of which has saved the necessity for what may be characterised as an outfall sewer.

In constructing the new sewers that have been required, I have provided for half an inch of rainfall per hour.

The rainfall in Reading for nine years has averaged 26·08 inches per year, and during the last four years there has only been four days on which as much as one inch of rainfall has been registered.

One of the most severe thunderstorms remembered in Reading occurred on the 13th of this month, when exactly one inch of rain fell in three-quarters of an hour; this, as might be expected, was more than the sewers could take, and many of the streets were for the time flooded, but in less than an hour afterwards the entire flood had disappeared from the streets, leaving, of course, a large quantity of mud in the low levels. On this experience I am of opinion that half an inch of rainfall is sufficient to provide for.

The surface-water sewers are not ventilated except by the rain-water down-pipes and by occasional untrapped gullies, nor have I thought it to be incumbent on the Corporation or on any public authority to deal specially with water falling upon street surfaces which may be tainted by droppings or otherwise, when scavenging is properly attended to. I name this in consequence of suggestions being sometimes made as to the standard of purity of surface water that may be allowed to discharge into open streams.

I give, as follows, a description of the powers obtained under the Reading Corporation Act, 1881, to enable the Corporation to effectually carry out the separate system of sewerage and drainage and other details, and to establish them in a safe position with respect to a large proportion of the works that were then executed:

Power to deal separately with the drainage of surface water, and sewage.

To determine the responsibilities of the Corporation with respect to the combined drainage of houses.

Power to make and enforce bye-laws for separating drainage and providing efficient flushing apparatus to water-closets, and to provide penalties.

Power to deal with foul drains as nuisances coming within the meaning of the same term in the Public Health Act.

Power to provide against emptying cesspools into public sewers.

Power to object to inefficient drains communicating with a sewage sewer.

Power to enforce closing and filling up of cesspools.

Power to enforce disconnection of water waste-pipes from sewage sewers.

Power to provide and enforce penalty in cases of not draining houses into public sewer where such sewer is within 100 feet.

Additional power of inspection and provision for expenses of examination of work.

Power for the Corporation to agree to make drains at expense of owners, and to require prepayment according to scale in schedule annexed, and to have full power to do the same if they think fit.

To provide for penalties not otherwise provided.

All new houses are required to provide separate drains for sewage and for surface water, and in the case of properties built

before the passing of the Act, the Corporation have power to require the effectual drainage of such properties in like manner.

I may now point out the great inconvenience that would result in Reading from strictly enforcing the powers that have been obtained in consequence of the circumstances I have detailed in deferring the work of connecting the surface-water drains. The Corporation have just commenced extensive paving works, and if they were to exercise their power and require that all the rain-water stack-pipes should be immediately connected with the surface-water sewer, it would necessitate a serious cutting up of the streets across the footpaths that are about to be reconstructed; and to avoid such a general disturbance, which would greatly retard the paving work and render it for a time insecure, the Council have adopted the following resolution:—

"That in connection with the proposed new paving works the surveyor do recommend to owners of properties the sewage from which is not drained into sewage sewers to carry out the drainings of their premises before the new paving is laid down. That the surveyor do prepare a list of the cases (in the several streets to be paved) to which Section 29 of the Reading Corporation Act, 1881, applies, and that the Town Clerk be authorised and directed, upon such list being delivered to him, to serve notices under that section requiring the owners to execute the necessary works. That as regards stack pipes only those from new houses should be required to be connected with the underground surface-water sewers, except those in parts of old streets which are on an incline, and that in such cases (where a nuisance would be caused by the water running down the pavement) the connection be made with the underground sewers by the sanitary authority as a necessary incident of the new paving works."

If it should be the opinion of the Meeting that it would be useful to give in this paper the text of the special clauses in the Act referred to, I shall be pleased to append them.

For practical purposes I believe that the provision made for effectually carrying out the separate system of sewerage and drainage in Reading may serve for many other towns similarly situated, as nearly all towns have sewers which may be utilised for the drainage of surface water, where a separate and complete system of sewers for the utilisation of sewage may be absolutely demanded.

At the present stage of progress in connection with the sewerage

of towns, when so many different systems are tried, it is hardly my province to elaborate in detail what I may suppose to be a perfect scheme in which new sewers are required for the double system.

The experience that has been learned in Reading, I have thought would be useful to the Members of the Association, and if I have failed in my endeavour to give full details, I shall be pleased to give further explanation.

DISCUSSION.

Mr. J. Gordon: Mr. President and Gentlemen, I think this question, to very many Members of the Association, is a very important one—to my mind probably of greater importance than the admirable paper and discussion which we listened to yesterday on another topic. I have asked questions at former meetings with reference to this separate system of drainage, because I find myself placed under such circumstances that I have to consider some mode of dealing with the great quantity of rain-water which gets into the foul sewers—as I am accustomed to call them—which were intended to convey not merely sewage, but the whole of the surface water. I have no doubt there are many gentlemen here to-day, and in our Association, who have had like difficulties to deal with. Mr. Parry has, as you know, had an opportunity of dealing with the question, and it was to him that I particularly addressed my remarks at the last meeting, stating that I believed it would be the wish of the Members of the Association that we should have information from those towns which have been compelled by the force of circumstances, and by the peculiar physical features of their towns, to consider the question, and adopt this system either partially or in its entirety. The separate system has been understood, especially abroad, as an absolute separation of the rain-water from the sewage proper. Now I am quite sure, until we had the case of Reading, that it was never intended to be carried out with that completeness, and I shall not be surprised if we hear views expressed to-day that there are many towns where one set of sewers will meet the case completely and entirely. Mr. Parry did me the pleasure in March last to address a letter to me pointing out, as I had taken an interest in this matter, that it might be desirable, from my point of view, to state what would be the points on which information would be likely to be desired. I replied to that letter

and the points which occurred to me at the moment of writing were as follows:—

1. Do you insist on a duplicate sewer in each street, and a duplicate drain to each property?

2. Do you make this retrospective, and if so, do you not find considerable difficulty in enforcing it, considering that the greater portion of the houses were no doubt drained to the town sewers before this system was determined on?

3. Is there not some liability, in future alterations or additions to drainage of properties, to get foul drainage into surface-water drains, and *vice versâ*, so that the surface-water sewers become contaminated and rain-water finds its way to the foul sewers, which it was intended to exclude?

4. Is there not, in fact, likely to be a tendency on the part of builders to use the shallow sewers for foul drainage, if not carefully watched, and have you any special means of distinguishing between the two, other than the depth?

5. What is your experience, or what is likely to be the effect upon the deep sewers, of taking all rain-water out of the road in regard to their self-cleansing properties, without special flushing arrangements?

6. What is your experience of the self-cleansing properties of surface-water sewers, or what special flushing arrangements do you find necessary?

7. What is the rainfall of your district: that is, what is the maximum in 24 hours and per hour, and in what space of time has the maximum per hour been reached?

8. How much rainfall do you provide for in calculating for your storm surface-water drains?

9. If a new system were being designed for a town on the separate system, on what principle would you determine the foul-water sewers, on the assumption that all rain-water reached the storm sewers?

10. How far is it necessary to ventilate the surface-water sewers, because, if surface gratings be used, it multiplies the objections to such gratings?

11. In large towns with great traffic, there must necessarily be a considerable amount of pollution even from surface drains to the streams into which they flow. Can, therefore, surface drainage be allowed in all cases to pass into the national streams?

These were the points, as already stated, which occurred to me

when I sat down to reply to Mr. Parry's letter. They are somewhat numerous, no doubt, but I think you will probably find there is hardly one of them which is not of interest in considering this subject. Mr. Parry has given us a considerable amount of valuable information with regard to the system carried out in Reading; but I was not aware at the time I put the questions I did to him at the last Annual Meeting, with a view of getting the information, that this system had already been brought before the Association. I find that so far back as 1873 you had a paper from Mr. Monsen on the separate system as carried out at Halstead, Essex. Mr. Monsen gave some particulars which were very valuable no doubt for the place to which they applied. He said: "Foul-water sewers had a minimum fall of 1:273, and are flushed from the water mains. The advantages claimed for the separate system were, that it combined efficiency with economy, and was especially applicable to country towns, although with suitable modifications it might have been applied to the metropolis, and thus have materially reduced the first cost of the main drainage and saved a large annual outlay for pumping water that ought to have been conveyed to the river at once, without being contaminated with sewage." Mr. Angell, who was President on that occasion, said "that the separate system must be adopted, if the sewage was to be disposed of by any chemical process." Two years later Mr. Parry dealt with the sewers of Reading, and touched very slightly on the contemplated separate system. Now, I have had to design sewerage systems for a considerable number of towns, ranging from a population of from 20,000 to 240,000, and therefore the question of separating the surface or rain-water from the sewers proper came before me, and very prominently in one particular case. In dealing with the towns to which I am alluding—continental towns—I had very little difficulty in any of the cases in so arranging the sewers that their size should be commensurate with the work they had to do in the dry summer months, when they had sewage proper only to carry. I was enabled to divide the towns into zones, and treat them separately, and to devise means of carrying off the storm-water after heavy rains had washed the sewers pretty clean. Immediately the sewers began to fill up they overflowed into the storm outfalls, and by these means, as I have already said, I was able to confine the sewers within reasonable limits in the matter of size. I therefore held the view at that time—and I am not going to indicate that I have in any way changed my opinion—that there

were many cases, indeed a very large number of cases, where it would not be necessary to adopt anything like this so-called separate system. In the year 1876, a year later than the paper read by Mr. Parry—though I had then no knowledge of it, or of Mr. Monsen's paper—I was called upon to design a system of sewers for Munich, the capital of Bavaria. I found myself face to face with this very important question—Are we to have a system of sewers for this city which will deal with the whole of the rain-water falling upon the yards and streets and roofs of the houses, in addition to the sewage proper? The city of Munich is so situated, that on the left bank of the Isar, which runs through the town, the area is exceedingly large, and all sloping towards the river, divided into terraces running parallel with the stream. Taking the latest census, December 1875, and dividing the town into districts. I found the quantity of sewage produced, or likely to be produced within the next fifty years probably, from any given area, was very small indeed compared with the quantity of water to be provided for from the surface of the streets and yards. It became, therefore, very important indeed to consider the question of duplicate sewers; and the conclusion I came to was this, which I have roughly translated from the original in German :—

"In considering the sizes and system of sewers to be adopted for towns during the past seven or eight years, the authorities of several English towns have been under the necessity of taking a somewhat new view of the case, in consequence of its being more incumbent upon them than formerly, in carrying out sewerage works, to avoid any pollution of rivers or running streams, which has involved a clarifying or purifying of the sewage, or utilisation of it. Where irrigation works were projected for towns so unfortunately situated that the sewage had in many instances to be pumped to a great height, the system now known as the separate one seemed to be the one to which recourse must be had; that is, the sewers proper, or what may be called foul-water sewers, need only be large enough to carry off the soiled water, or sewage from the houses, in order that the cost of pumping might be reduced to a minimum. The principle of the system consists of separating the rain-water from the sewage, or soiled water sent forth from domestic dwellings and manufactories, and in building separate sewers for rain-water carried direct, by the shortest routes, to the rivers and other available streams. The system has, however, so far as I know, nowhere been carried out in that completeness which its

name and the principle involved imply. Those who have adopted it have been satisfied to use and retain, as far as possible, the existing and mostly shallow sewers of a town for carrying off the surface waters, in order that the number and length of new duplicate sewers required for such purposes might be reduced to a minimum. If the separation of the rain-water from the sewage proper were to be carried out with that completeness which the name of the system implies, the cost of sewering of every town would undoubtedly be largely increased, because it would involve not only duplicate sewers in every street, but duplicate drains to every house and yard. And it must not be forgotten that, with the exception of the main-trunk sewers, the size of the sewers requisite to take the rain-water from the streets, roofs of houses, and yards, would hardly be influenced by the sewage from the houses intended to be excluded. Practically the adoption of the system is limited so far to the exclusion of as much rain-water from the new sewers as is possible by means of existing sewers to be retained for the purpose. In draining the houses, however, the rain-water from the yards and roofs of the backs of the houses is passed mostly to the foul sewers, in order to avoid the double system of drains. Reading was one of the first towns to adopt this system. The sewage has to be lifted there to a considerable height, so that there was every reason why the quantity of water to be lifted should be reduced to a minimum. The rising main has a length of about a mile, and was projected 2 feet diameter. To assume that, because the system has been adopted in special cases of this character, its adoption is justifiable in all other cases, as has been advocated by some, is in my opinion a mistake. On the contrary, I think there cannot be any doubt that the peculiar physical features and circumstances of each town alone must decide the system to be adopted. I can, however, imagine circumstances under which it may be somewhat difficult to decide between the adoption of the separate and the more universal combined water-carriage system."

These were the views I expressed in the report made to the authorities of Munich in 1876. I did not at that time suppose I should be placed under circumstances so very soon afterwards which entailed the reverse, to some extent, of that opinion. I find, however, that in 1879 another paper was read on this subject, so that it is one which has been constantly before the Association; and I think it is probable that it will come before it again frequently before we have come to any decided opinion as to its applicability

generally to towns. Mr. Angell read a paper in London in 1879, and he said that, in his opinion, "the system must be eventually adopted in the future, under the new obligations as to sewage purification." I have not gone carefully through the discussion which then took place; but Mr. Pritchard, who took part in it, "thought there were difficulties in the way of its adoption in large towns, and triplicated sewers would be necessary." Mr. Fox, who also joined in the discussion, "thought it cheaper to pump the water from yards than to lay separate drains." Mr. Vawser spoke on that occasion, and read a paper at the Leeds meeting in May 1880. In that paper the question was much more fully gone into than it had been on previous occasions; Mr. Vawser summarises the conclusions to which he had come as follows:—

"That a perfect system of town drainage must provide for the removal of all liquid refuse, together with the largest rainfall known to have fallen in the district.

"That rain-water falling on paved surfaces, in thickly populated districts, is known to pollute fresh-water courses, and in the present state of the law should be purified before it reaches a stream.

"That sewers and sewage purification works should be designed to deal with the maximum flow of sewage due to the population, together with waste liquids from manufactories, that cannot be otherwise conveniently disposed of, also with the rainfall at the rate of 1–100th inch per hour, or ¼ inch per day over the whole district drained.

"That falls of rain greater than ¼ inch per day may be safely turned into natural watercourses, and sewage diluted with ¼ inch and upwards of rainfall may be diverted into watercourses without undergoing purification.

"That a system of town sewers for the separate removal of surface water possesses no advantage over common sewers capable of removing every class of liquid refuse."

The last conclusion to which Mr. Vawser came on that occasion coincides very much with that I came to in 1876 in dealing with the sewerage works of Munich; but which was not based upon such a thorough investigation as Mr. Vawser thought fit, and I think very properly, to undertake before he came to his conclusions. Mr. Vawser went to the extent of getting out for a certain town an estimate of sewers based upon the assumption that the sewers should carry not only the sewage but the rain-water, as had been the practice hitherto in most cases. He then went into the question

of dealing with it on the separate system, and the estimates which he made showed that in that particular case for one portion of the district there was really, as far as cost is concerned, no advantage either the one way or the other, while for the high-level district the cost of a duplicate system amounted to nearly two-thirds more than the other. It is no doubt very desirable that investigations of this character should be made in every case, as you would then not be dealing with the general assumption that the separate system is desirable on all occasions, but have facts and figures to guide you to a decision. In the paper read previously by Mr. Angell to which I have already alluded, he said:—

"Speaking in general terms, the surface drainage of towns found its way into natural channels before the handsome pumping-station down in the valley—the pride of the sanitary engineer—was built. The engineer, improving on nature, has diverted the surface drainage from its score or two of natural outfalls into his big 'main sewer,' 'discharging into the well,' from whence it has to be lifted again by machinery, most excellent for the purpose; but a still more excellent plan would have been to have 'left well alone.' Again, when surface waters are thus collected, and concentrated into given channels, the inconveniences arising from the flooding of basements constantly arise, and where pumping engines have to be depended upon still greater troubles occur."

Mr. Angell said further in that paper:—

"The separate system of course can only be carried out in general features, not in every detail. It would be a mistake to have a duplicate set of drains to each house; back yards would generally drain into the soil sewers, but, for the most part, roofs can be drained into the road channels, or surface drains. About 90 per cent. of the surface waters may be diverted without causing any difficulties in detail."

So far as I have gone there is a considerable diversity of opinion on matters of principle; and it was because at the present moment I have to deal with circumstances which render it necessary to relieve the town sewers—as Mr. Angell has found it necessary at West Ham; no doubt originally built sufficient for the purpose of sewage and rainfall, but in consequence of the large and increasing population, and extended area of streets, roofs, and yards drained to and filling the sewers much more rapidly than before—that I thought we should have some authoritative paper from some town which had dealt with this question more elaborately and more

in detail than most towns in the kingdom; and I believed that that was the case at Reading. I certainly understood Mr. Parry, at the time he alluded to the subject at the former meeting, that the separation of the surface water from the town sewers had been carried out completely. I have always seen great difficulty, the same as Mr. Angell has done, in insisting on duplicate drains from houses; and we have heard from Mr. Parry, I think, that they have not after all carried out the system to that extent at Reading that had been supposed. If they had they would have gone further than any other town with a large population had done. We have had some interesting details, but I should have been glad if Mr. Parry had added to his paper the length of the sewers originally constructed for carrying sewage proper, and the length of the sewers, either adapted as old sewers or executed as new sewers, for the special purpose of carrying off the rain-water, because I think that would have given us a clearer idea of the actual extent to which it has been applied at Reading. It would also have been of interest if Mr. Parry could have given the number of houses (I think the paper does not give it) to which the system of duplicate drains has really been applied; because, if it has only been partially carried out, it is misleading to go away with the idea that it has been applied at Reading with the completeness already alluded to. Before alluding to the circumstances of my own town, I should just like to say a word about old sewers. From my own experience of them they are inferior in this country to old sewers met with in many towns on the Continent. I would say to those who may have to advise their local authority to adopt a duplicate system either partially or wholly, to be chary in adapting existing sewers of ancient date, for though they were originally intended to carry surface water only, they have become in the course of time sewers for general drainage purposes. They were, many of them, formerly ditches, built over as the ground became built upon, and are constructed too frequently without any reference to general levels or lines, whilst in the quality of workmanship they are often miserably bad. They have become so polluted, that unless you can thoroughly cleanse them from silt and sewage, you will find in adapting them as storm-water sewers to relieve deeper sewers, you have not relieved yourselves of the nuisance arising from them, as they will continue to give off deleterious gases, and pollute your watercourses, until they have been thoroughly freed from all deposit and been structurally improved. At Frankfort my coadjutor and I set our faces so com-

pletely against the adoption of old sewers that we discarded them entirely, and we did not merely do so by not using them, but, after the main sewers of the town were completed, we set to work and had the houses drained in blocks to the new sewers, after which the ramifications and connections of the old town sewers became useless, and were therefore taken up and filled in, having been previously surveyed and carefully plotted on to large scale plans; and I believe that is the only way to ensure sound sanitary conditions. Turning now to the particular case of Leicester, I have no doubt many of you represent towns similarly situated. It is, however, a more striking case than the one to which Mr. Angell alluded when he spoke on this subject. Leicester was one of the first towns to carry out a complete system of sewers, and it was considered, I believe, that its sewage purification works were models of their kind. The sewers of Leicester were carried out as far back as 1854; and designed, no doubt, for the town as it then existed. But the town has more than doubled its population since then. In 1854 the population was somewhere about 63,000, and now it is 130,000. It follows, unless the engineer—as I believe every engineer ought to do, though possibly we ought not to find fault with what was done thirty years ago—took into account the probable increase of the town, and the area that would eventually drain into the sewers, although much of it might then be merely a suburban district, that the sewers would become in the course of time inadequate. The increased area built upon is greater in proportion than is represented by the increase of population, because as towns of this kind extend, enlarged ideas prevail, and more space is required for broader streets, and for larger buildings with increased ventilation space at the rear of them. The greater area thus built upon naturally delivers such a large quantity of rain-water to the sewers as to be difficult to deal with. The position we now find ourselves in is this, that the sewers as originally constructed are totally inadequate to carry off the quantity of rain-water—even after moderate showers as was intended they should—without bringing into play the storm overflows, laid at too high a level to prevent great inconvenience arising from the backing up of the sewers. We have to pump the water into tanks for purifying before it flows into the river, but provision was made for extreme rainfalls by putting in an overflow about eight feet above the invert of the main sewer. It was no doubt intended that the pumps should lift the sewage so long as it was

likely to pollute the stream, but after the sewer had been washed thoroughly clean by the first part of the rainfall, the dilution of the sewage would be so great that the water might then pass direct into the river. That is a view which may fairly be taken, unless the stream into which the slightly polluted storm-water is discharged be very small indeed. But when you have to utilise the sewage, as every town now has to do, and to deal with circumstances such as I have described, and it turns out that the sewers originally built are not large enough for the altered circumstances to carry the quantity of water falling in the district to the point at which you have the outfall, I ask what is to be done? Are we to begin afresh with a new system of sewers? or to relieve as a first step the existing sewers by building storm-water overflows? The latter may be adopted under circumstances more favourable than those with which I have to deal at Leicester, and it is a course which is adopted in many towns. But when you are not able to lay down relief sewers at certain points, and divide your town into zones, at such a level as to afford relief, until the sewers are placed under such pressure that cellars are flooded, the putting down of storm-water overflows can never be a satisfactory solution of the difficulty. They would, in fact, not be of any use to the deep-lying cellars. Looking, therefore, at the whole case, I have been driven to the conclusion —as was evidently the case with my predecessor—that there is only one way out of the difficulty, and that is to adopt the separate system, so far as to lay down duplicate sets of sewers in every street, in order to take as much of the rainfall falling upon the streets and front parts of the houses as is possible. In that way we hope at Leicester to relieve ourselves very considerably and not to be under the necessity of reconstructing the whole of our main sewers. We wish at any rate not to be under the necessity of stopping our pumps for almost every shower of rain, as we should then only have to deal with that portion of the rainfall which falls upon the yards and the roofs of the backs of the houses. To attempt to make duplicate drains imperative and retrospective in a town of the size of Leicester seems to me a proposition which could hardly be entertained, on various grounds. I have not attempted to advise my Committee in this direction, and it was because Mr. Parry had had the courage to adopt the plan in Reading that I was anxious to know how far it had succeeded there. As you have heard, it is considered to be successful; the question is, whether it is possible for other towns to get the same powers if they should be

under the necessity of making the system retrospective. What we have done is this—we have had under consideration during my period of office the issuing of new local bye-laws. Like many other Corporations, the Leicester Town Council found it unadvisable to adopt, or have forced upon it, the model bye-laws of the Local Government Board; and I believe, if those bye-laws are carefully considered, they will be found in many respects equally unsuitable for many other large towns. It was therefore attempted to incorporate in a Bill before Parliament in 1881 new bye-laws that would suit our circumstances. We have before heard allusions to Lord Redesdale's action in the matter of private Bills, and when our Bill came before his Lordship it was found that he wished us to adopt in their entirety the model bye-laws of the Local Government Board, or he would in all probability oppose every suggested alteration we proposed. Our Town Clerk advised that we should have to be content with incorporating our then existing bye-laws into our Local Act, with a few amendments, which gave us power to issue rules and regulations which we thought would meet our case. Under the authority of these bye-laws, incorporated in the special Act, I stated that, circumstanced as we were, we ought certainly to insist on a separate system in all new streets and buildings in future. This regulation was made: "Every new street must be provided with duplicate sewers, wherever practicable, and unless specially sanctioned otherwise by the Town Council—one for storm-water and the other for sewage." This is now in force, although we met with difficulty in the first instance from those to whom it applied. The bye-laws, however, were not issued without great care and thought, and we took the precaution of first submitting them to those who would be likely to have to deal with them, or to raise opposition to them. They were drafted by myself and then submitted to our Town Clerk, who considered them entirely within the powers given by the Act. They were then referred to a sub-committee, which had several meetings, and then they sent the bye-laws in proof to the master-builders of the town and also to the Institute of Architects at Leicester, with a request that they should make any suggestions they thought necessary, and they would be considered. These gentlemen availed themselves of this opportunity, but I am glad to say the suggestions they made were very few. Then they were invited to support the suggestions they had made by attending before the Committee and discussing them. This having been done, the bye-laws as amended went to a larger com-

mittee, and eventually to the Town Council, and at a special meeting for that purpose they were finally adopted. Now, with regard to the drains for houses.

Mr. BUCKHAM: Is there any limit to the time a Member is allowed to speak on one subject?

The PRESIDENT: I am not aware there is any rule limiting the time that a Member may speak, but Mr. Gordon will see that time is getting on.

Mr. BUCKHAM: I thought Mr. Gordon was getting a little away from the paper when he quoted the bye-laws relating to a particular town.

Mr. GORDON: It is only leading up to what we have done. We insisted on duplicate sewers in new streets and duplicate drains to new buildings. We hope to do some good with that, but the question of making the regulation retrospective is one of such great importance that I should like to hear some expression of opinion respecting it from gentlemen who possibly may have been trying to do what Mr. Parry has done in Reading. Of course I have directed particular attention to Reading because I was not aware that any other town had attempted to go so far. I am sure no one is more grateful than I am to Mr. Parry for having furnished us with his paper, and giving us an illustration of what may be done, where there is the will to do it, as appears to have been the case at Reading. Mr. Parry is entitled to our thanks, especially as his paper is not merely theory, or an assumed case, but the results of his experience, and of what has been practically carried out. I have ventured to invite further discussion by giving you the experience of Leicester, and describing the difficulties by which we found ourselves as it were almost driven to the adoption of the separate system. We have already carried out about 11½ miles of storm-water sewers, and therefore we may be supposed to know some little about it. When you have carried out a length of sewers of this extent, varying from 5 feet to 9 inches in diameter, and feel that this is only a portion of the work before you, it is evident that it becomes a matter of great importance on the score of cost. I do not wish it for a moment to be understood by this meeting that I have changed my opinion at all with regard to the separate system. I believe, although it has been admirably carried out at Reading, and at Leicester we are under the necessity of adopting it partially, that for large towns it is an expensive system, and that authorities will pause before they adopt it. Perhaps I may

be wrong. Mr. Angell and others believe the contrary, and I believe Mr. Monsen does too; but the more we know about the economy of the system from those who can show it to be economical, the better.

Colonel JONES: If you will kindly bear with me for a few minutes, I will not take up much of your time. As you are well aware, I have been very much interested in this separate system for a very great many years; and if Mr. Gordon will refer to Mr. Alderman Kempson, who was Mayor of Leicester some fifteen years ago, he will find I took the utmost pains to try and impress on that town the necessity of separating the sewer from the surface drainage, but I was "pooh-poohed" at the time, on the ground of expense. A few years ago Alderman Kempson came to me at Wrexham, and told me the Leicester Corporation had voted 12,000*l.* to do what I implored them to do twelve years before. The natural rainfall has fallen upon the land always, and I take it the agricultural engineer should carry this water off by the shortest cut, as fast as ever he could get it away, to the nearest watercourse. He does this not only for the benefit of the crops, but of the animals that live upon the land. If, on the other hand, you are going to build a town upon such land, you should arrange the drainage upon the natural lines laid down for you by Almighty God in the showers beforehand. You should take care there is ample room for all the rains which come from the heavens to get away as quickly as possible. Then you should provide separately for the foul water you have made from your water supply. We have fallen into the error of attempting two things together which should be distinct. Drainage is for the removal of water which comes naturally; sewerage should be for the removal of water which is brought into the town for domestic and manufacturing use. Any water likely to be foul should go into the foul sewers, but showers—rainfall—should be got away rapidly by storm-water drains, because the difference of cost arises from this, that if you take storm-water into the sewers you have to take it a long way, and dispose of it there at great expense. If a town is reasonably scavengered, the surface water may go into the nearest watercourse, and probably would not have to go many yards. Shortly after visiting Leicester I took the sewage farm at Wrexham, and I did so principally to illustrate the separate system. I saw it was a town that could with remarkable ease be divested of the surface water, which could go into the river at trifling expense. I knew the maximum of the sewage I had to deal with, and I expected I should

very soon force this on the common sense of the Corporation, and induce them to divert as much as possible of the surface water. I did not ask them to make duplicate drainage or separate sewers. However, I have been eleven years in enforcing that much on the Corporation, and at last had to resort to litigation to drive them to do it. I have just succeeded in getting what I originally proposed—that they should divert the surplus surface water into the brook, which, I think, is a perfectly good plan. This is not a manageable quantity to deal with on the sewage farm. As a consequence of arbitration I have compelled the Corporation to provide me with beautiful new depositing tanks of my own planning, which I shall be very pleased to show to any gentleman; and to show you the plan of taking the solids out of the sewage, which is an advantage on all irrigation farms, because in very few cases is it desirable to put sewage on mixed with sludge. I only mention this to show how long it takes to get practical ideas carried out. It was arrived at simply because of the foulness of the overflow, which Mr. Vawser thinks of no consequence after a shower has washed the streets clean; but if you take a small town, with a small stream made foul by the sewage-polluted storm-water of a large district getting into it, it becomes a great nuisance.

Mr. JERRAM: This is a most important matter, this question of separate sewerage, and what we want is to get at the results of our practical experience. Having a district of some 26,000 population, growing at the rate of 600 houses a year, it may be some advantage to give the results of the separate drainage system at Walthamstow, London. There is no doubt about it that, in laying out a system of drainage, very much must depend upon the physical circumstances of the district. If you have a district with a brook running through it which used to take the rainfall naturally from the surface of the ground, it must be self-evident that it must necessarily be much the cheapest way to have small surface drains to take the rain-water off the streets (and from that portion of the district more immediately under the control of the local board) as direct as possible into the brook, the natural drainage outfall. But where the river is far off—if the town is on the side of a hill and the river some little distance away, and you have to increase the size of your sewers considerably towards the outfall, it will then become a matter of calculation which will be the cheapest—to have two sewers, one for sewerage, and another for surface-water drainage, or one large sewer taking both rain-water and

sewage. But where a brook runs through a district, there can be no question the cheapest method is to run your water drainage from the roads as direct, and in the smallest pipes possible, to the brook. This is the position we are in at Walthamstow. We have been carrying out the separate system in its entirety. We have not been content to take merely the drainage of the streets, but we have insisted there shall be two drains to each house, and I find enormous difficulties in carrying this out. When plans are sent in, in nine cases out of ten the drainage is shown wrong, and the sewage water is shown running into the surface-water drains. Although drains are inspected, and no drain is allowed to be covered up until it has been inspected by myself or my assistant, yet the result has been, after three years' experience, that I find all our inspection is in vain. Of course the surface-water drain is the shallower—only a foot or two from the surface—whilst the soil sewer is much deeper; and it is very natural, when the houses are out of our control, that when any man is sent to attend to the drains, he scratches the ground, finds the rain-water drain, and connects the sewerage drainage with it. What is the result? All the thousands of pounds we have spent in cleansing our brooks will be of no effect, as in a few years they will be almost as foul as they were before we started draining the district. Therefore I have come to the conclusion that it is very unwise indeed to attempt to separate the surface water entirely from the sewage, but only as far as you can have it under your entire control—from the fronts of the houses and the streets. This, I think, is the best possible plan to adopt; and that the rainfall from the back yard and stack-pipes should run into the soil sewers, and that there should only be one drain to each house. That is the conclusion I have come to after three years' experience, and I have frequently had great difficulty in finding where wrong connections have been made. The result then is, that I should say have only one drain and sewer, and no separate system, except under your own control. There is one matter that has not been gone thoroughly into, and that is the size of sewers for surface and sewage drainage. We all know how small the flow from real sewage is; a very small pipe indeed would take the sewage from houses, but for the storm-water we must have sewers large enough to take the most extensive storms, and in that way we get very large sewers. I think we are making a mistake, where we have a duplicate system, in making our soil sewers too large. They only

become reservoirs for sewage gas, and I think a question which we should discuss at some future time should be the size of sewers where the duplicate system is adopted. This is my experience, and I think it would be an advantage if others who have tried the separate system would also give their experience. It is only a few years ago that the idea was started, but now we have actual results; let us know them, and then we shall get correct data to work upon.

Mr. J. LEMON: I was somewhat surprised to hear that this is a new system. So far as I know, the separate system has been discussed ever since the time when probably the oldest persons present in this room were boys. The General Board of Health first recommended the separate system, and Mr. Edwin Chadwick, the great sanitary reformer, was one of its strongest advocates. You know the old saying about the rainfall to the river, and the sewage to the land; but even Mr. Chadwick, who was certainly as sanguine in his proposals as anybody I ever knew, did not go to the extent of an entirely separate system of drainage. Mr. Chadwick said: "I am in favour of admitting the roof-water from houses, and the water from paved surfaces, such as streets, mews, courts, alleys, and paved squares." So even he was not in favour of the system in its entirety. I will go further, and say that there is no town in England where the separate system is carried out in its entirety, so far as I know; and I will go even further, and say that if it was carried out next week it would not last a month. I am an advocate of the separate system, and doing everything I can to enforce it, but I should be sorry to see the principle laid down that the separate system is applicable to all towns under all conditions. I think this is the mistake engineers make. We see an instance of this in the remarks made by Mr. Gordon. He saw a discussion on the subject, and was misled by it in the report which he made to the authorities of Munich. I say the separate system is a system only applicable under certain conditions, which will depend upon the particular circumstances of each case. I classed them at one time, and stated where I thought the separate system applicable. I put them under these heads: (1) "Towns where it is necessary to pump the sewage to the land for purification or utilisation," and (2) "where it is necessary to pump sewage for treatment by precipitation or intermittent filtration." I would also say, when sewers are dead-locked in low-lying districts, it is necessary to keep out as much surface-water as practicable; but I

am not prepared to go further. I agree with Mr. Pritchard that there are towns where the separate system would be unadvisable. Some of the towns in the Midlands, for example, where the dry system is in operation, and large and densely populated towns. In these cases it is clear you had better only have one system of sewers. Then, as regards its practical application, I think it is a great stretch of authority on the part of any governing body to compel an owner of property, after he has been called upon to drain his house into the sewer, to put in another surface drain. I think that is a most extraordinary stretch of authority, and if they did compel this to be done, no practical good would result from it. Take the case of an ordinary house—I will not refer to back yards and paved areas, because Mr. Parry says he does not include those—but take any ordinary house with back gardens. Take the house as 20 feet wide and 30 feet deep, and you have got 50 feet of depth to deal with, the remainder goes into the ground, sinks into the land. Supposing you go a little further and take in the back yards, what is the result? Take my own house as an illustration; we have paved yards, as most such houses have, attached to the kitchen. In this paved yard we have got a yard gully, which is attached to the drain. Now, supposing that was connected with the rainfall sewer, according to Mr. Barry's system, what is there to prevent the servants throwing kitchen slops or anything else down this drain? Of course they would do it; I believe they would do it in most cases. Then the cost of gullies for the separate system would simply result in failure. There are many houses in the metropolis and large towns with slop sinks common to many houses. I say in this case it is quite impossible to carry out the separate system, because the slops would constantly be thrown down so as to reach the rainfall drainage. It is important, however, where the sewage has to be purified, to do everything that can possibly be done to keep out the rainfall. I quite agree with Mr. Jerram that this should be restricted, as much as possible, to the area under the jurisdiction of the local authority, because that is the only district over which you can exercise efficient control. I have taken a great deal of trouble in this matter at the city of Winchester, where there are exceptional facilities for getting rid of the rainfall. We did there what is recommended by Mr. Jones. The rainfall went away long before the town existed, and I left it untouched, and it goes away into the nearest watercourse. I simply laid down a separate system of sewers and took

away the sewage only; and the Corporation passed very elaborate bye-laws to prevent rainfall drainage being connected with the sewers. What is the result? I find, where there is a shower of rain, that the quantity at the pumping station is enormously increased. Where does it come from? Not from the gullies in the streets, because there is not a single gully connected with the sewers. It comes from the back yards, where owners connect their stack-pipes and their drainage in the yard with the sewers. If the system recommended by Mr. Parry is carried out, it will be found, in less than ten years, that a great deal of the system of double drains will be carrying not merely surface water, but polluted water also.

Mr. PRITCHARD: The paper read by Mr. Parry is one of considerable interest, inasmuch as it has evolved lengthy discussion, and I am sure we must all feel obliged to Mr. Parry for having afforded this opportunity of considering the separate system. This subject has cropped up at both our district and annual meetings, whenever the disposal of sewage has been discussed. It has been thoroughly ventilated, but not too much ventilated, because this is a matter which requires grave consideration. I have not altered the opinion I expressed some years ago, and since then I have had many opportunities of putting my theories to the test of actual practice in the construction of works in different parts of the country. I agree with Colonel Jones, and endorse what was said by Mr. Jerram, that a great deal must depend upon the local circumstances connected with a town. It has been said, that although formerly in favour of the separate system, I am not so now. I am still in favour of the separate system, but it must be justified by the local circumstances—where the surface water may be fairly and readily turned into the natural streams. To say that I am not in favour of the separate system would be inconsistent, because in many towns I have constructed works turning the rainfall to the streams and natural watercourses. But there are considerable difficulties in the way in some cases; for example, in such large towns as Birmingham, Leeds, or Manchester. To carry out the separate system there, would require, as I have before maintained, a triplicate system of drainage. The surface water from the streets in the towns I have named would be quite unfit to pass into the watercourses, which would have to be purified before it could be turned into the natural streams. In other instances the rain-water passes through street gullies, and in

many of the courts they are the only receptacles for the liquid sewage from the various houses and tenements in the courts. That being so, it is absolutely necessary that there must be one system only. An engineer may be in favour of the separate system, so far as he can apply it; but there is nothing inconsistent in his not adopting it where the rain-water is as bad as sewage, because here he is compelled to say, "there can only be one system." No one knows better than Colonel Jones, who has suffered so much from surface-water, what injury is inflicted upon those engaged in disposing of sewage by sending water into the sewers which might advantageously be turned into the natural streams. The strict system of duplicate drains for houses I have always thought a mistake, and I am glad to find, from the experience of Mr. Jerram, that it is a failure. I would just make one or two allusions to the paper read by Mr. Parry, and ask that there may be some explanation given. We are informed—although I cannot but think it is an error—that provision is made at Reading for the removal of ½ an inch of rainfall per hour. I have always looked upon a rainfall of a ¼ of an inch in 24 hours as being something considerable for removal. Whilst sitting here I have made a few calculations, which therefore may not be quite correct. I find Mr. Parry says that a 6-foot barrel sewer takes the whole of the sewage; and roughly calculating the velocity of the sewage at 3 feet per second, this sewer would deliver 44½ millions of gallons in 24 hours, or something like 32,000 gallons per minute. I have also taken the effect of a rainfall of ½ an inch per hour, on say 1000 acres as representing the area of Reading, assuming that the whole of that quantity falls on paved surfaces. Now I find that the quantity of water taken by this sewer of 6 feet diamater would be approximately 11,311,000 gallons of rainfall. That would represent 377,000 gallons per minute to be removed. [Mr. PARRY: Never intended, you know.] I only wanted to show that a sewer to do this would require more than eleven times the capacity of this 6-foot diameter sewer. I made this allusion for a double purpose. Colonel Jones says, "Make your sewer large enough to take the rainfall." But where shall we be if we make sewers like tunnels in small towns? I simply instance Reading, which has a sewer of such large diameter for a population of 43,000, to show the difficulties which must be encountered by engineers if they have to make provision for the removal of all the rainfall. At present it may be easy enough, with only 100 acres of paved surface in an area of 1000, but as the

sewer must be large enough for the whole watershed when built upon, the cost will be increased very considerably. There is another point in the paper which shows that in Reading they have very liberal ideas. They are very lavish apparently in the supply of water. I find 1,813,000 gallons are supplied per day to a population of 43,000, which gives the enormous quantity of 42 gallons per head per diem. Gentlemen present may remember a case of an intermittent supply where some 40 gallons per head were consumed per day; but which by supervision and a constant supply, with careful inspection, was reduced from 40 to 19 gallons per head of population.

I consider the powers of the Corporation of Reading as to a duplicate system of sewers enable them to inflict great injury on householders. I am very sorry for the householders, and I should be very sorry to see other towns follow the example of Reading. Notwithstanding that some of us may express adverse opinions—and express them rather strongly perhaps—we must all feel glad that we have in this paper so much material for discussion given us, and we are much obliged to Mr. Parry for affording us the opportunity of further discussing this important matter.

Mr. C. Jones: Just one word on this question. As each annual and district meeting comes round, we realise more and more that this is one of the great questions—the great question perhaps—on which we want to be at home. It is a question which is assuming a serious character, when we find an important town like Reading laying down a law which to my mind is most prejudicial, and most detrimental to the best interests of a town. I do not want to use very harsh words, but I am sure my friend Mr. Parry will excuse me if I do, as I generally speak straight to the point. There have been one or two remarks made which recall the familiar saying, "Every tub must stand on its own bottom." The physical characteristics of a town must to a great extent influence the system of dealing with the sewage. There is another point, however, that we must consider—*we* are sanitary engineers. Our first object should be, as such, the health of a town. You may remember, gentlemen, that in my Inaugural Address as President last year, I touched somewhat on this matter, and the town which was to be built, some day or other by a very prominent gentleman, a well-known physician and sanitarian. Hygeia has not yet been built, fortunately; but if it had come into existence, in a few years zymotic disease would have made it its home. There is only one

thing which by any possibility can deal with the difficulties which gather round our sewers—large or small—and that is the rain, which God Almighty sends us; and I say to take it entirely out of the sewers—for such is what it comes to—is to destroy the only means we have of dealing with difficulties which gather around as towns increase in size. It is a very serious matter indeed, and one that I cannot refrain from expressing myself strongly about. I admit that Colonel Jones, whose experience on this point is very large, would say, Give me the minimum of waterworks sewage. But why? Because he has a regard for the requirements of Wrexham? Not a bit of it. He wants you to go down to his farm, and then to say to you, "Look, gentlemen! there is a mangel wurtzel for you"; or to put his arms round a huge cabbage, and triumphantly exclaim, "There's a cabbage!"

The PRESIDENT: You could not get your arms round some of them.

Mr. C. JONES: No, it took two of us to grasp one, and you could not get more than two into a tumbril. These are facts. People at Wrexham do not care whether cabbages grow to this size, but they do desire that the death-rate shall be kept as low as possible. It is the same with every other town in England, and it really becomes an important question, when we propose to eliminate from our sewers that which alone enables us to deal properly with them. I defy you and all the engineers in England to devise a system which shall clarify the lateral drains if we have four miles of lateral drains to one mile of sewer; and as to housemaids flushing the sewers, they would be as likely to put the water into the wrong drain as into the right one. I daresay you all attend to these things yourselves, and if you do not, I daresay they are forgotten, but the best we can do will not equal the arrangement of Providence. We need to be very careful and watchful in this matter. I approve of the separate system for roads, but as for houses and back yards, I say, let them have all the rain that God sends. Then we shall keep down the death-rate, as I am happy to say mine is, to about 12·2 or 12·4 per 1000 inhabitants. I do not care whether things grow or they don't. I have a little farm, and I know the less there is there, the better it is for the ratepayers. Mr. Parry said something about 600 acres; our friend, the President, has only 300, and I am sure he is better off. The less land the more profit; the more land the more anxiety. I am not going to touch on the milk of lime process, which was in use twenty

years ago, and I have stuck to it all through, but it has become popular again, and if properly managed you need only have the minimum of land. One acre will be sufficient for 1000 people; that will tell upon the rates and upon the sanitary condition of the people too. I say again, Let all the water God sends go down your drains. Of course there must be some speciality and peculiarity for every town. I said to my friend Sherman, who has just gone out, "You have no separate system, have you?" and he replied, "Not likely." I have just expressed these views, which you have heard over and over again, but this matter is so important, I think they want reiterating.

Mr. LEMON: Will you allow me ask Mr. Parry a question before he replies. I use Field's flushing tanks. I wish to ask what he would do in a case like that? Would he compel the owners to remove the flushing tanks, or leave them as they are?

Mr. VAWSER: I should like to know a little more respecting the Act obtained for Reading in 1881, which gives these powers. I do not quite understand whether any special legislation was absolutely necessary, but it appears additional powers have been obtained, in order to carry out this duplicate system. I think it would be interesting to all of us if Mr. Parry would tell us the nature and extent of these additional powers. I should just like to say a warning word to any young engineer—if I may be permitted to style myself an old one—not to adopt a dogma such as Mr. Parry appears to have laid down: he says the maximum rainfall amounts to an inch and a quarter in an hour, and his sewers will carry off half an inch. If any engineer adopts this theory he will not relieve his Corporation from their liability.

Mr. HALL: I have no difficulty in my town, being at the mouth of the Tyne and discharging into the sea. Mr. Parry, however, says, "Every sewer is flushed once a fortnight, the greater part of them once a week, some twice a week, and others three times a week, according to circumstances." My opinion is, that if the rainfall got into the sewers this expensive system of flushing would not be necessary. It appears to me to be very heavy and very expensive work, when these sewers have to be flushed twice or three times a week. If more rainfall was admitted into the sewers, as Mr. Jones has advocated, it would save a great deal of money to the rate-payers, and also be more efficient in practice. It struck me when he was reading his paper that this flushing must be exceedingly troublesome and expensive.

Mr. ANGELL: It is rather late, but I cannot allow this discussion to close without saying a word upon the monstrous absurdity, as I regard it, of attempting to carry out the duplicate system in detail. Generally, under the modern state of things, when you have to purify sewage, and that principally in tanks—for we seem to be getting back to tanks again—you require something like a constant flow, and know what you have to deal with. But I think it would be folly to attempt to carry the separate system beyond applying it generally to the streets and the roofs of houses. I think it monstrous that every house should be compelled to have a separate system of drainage, and it would only lead to the blunders Mr. Jerram has so graphically described. It is said that some persons may steal a horse, but others may not look over the hedge. Lord Redesdale would not allow the Leicester Corporation to introduce bye-laws, but Reading seems to have got most exceptional powers. In my paper in 1879, I said, "The separate system of course can only be carried out in general features, not in every detail." I have adopted the system so far as regards the streets. Mr. Gordon says he has provided overflows from the sewers to go into the streams. I do not think that is legal, because, under the Rivers Pollution Act, you must not make any new outfall into the river, and any sewage water which goes into the river from the overflow, legally comes within the prohibition. Therefore, if any private individual chooses to oppose it, it can be stopped. I know this as a fact, because in the river Lea, where all our water went from the higher level to the lower and had to be pumped up at great expense, we proposed to make an overflow into the river from the upper system. We were at once met by the River Conservancy, who opposed us until we got an Act. By an Act, and by an Act only, we got power to send our storm overflow into the river. I will not prolong the discussion, and will only say that whilst you should separate as much as you can, it would be absurd to try to carry it out in detail.

Mr. BUCKHAM: I should like to ask Mr. Parry a question. Is the flushing to purify or to remove obstruction? From my experience in my own town, it acts more as a purifier than as a means of removing obstruction.

Mr. COLTHURST: I will not detain you long, but I understand from the advocates of the duplicate system of sewers that they believe they will materially reduce the death-rate. Well, now, I have gone through the death-rate of Reading. Mr. Parry says

the average death-rate for the three years, 1873–1875, before the new system of sewers was carried out, was 18·116.

Mr. PARRY: No, that is when it commenced.

Mr. COLTHURST: I am taking the average of these three years. For the three years following it is 18·3, so that, notwithstanding this enormous outlay, I don't see that any good has been done in this respect by the duplicate drainage system.

The PRESIDENT: Of course I shall be pleased to hear any further remarks, but I would remind you that time is getting on, and we have still a considerable amount of work before us.

Mr. SPENCER: Before Mr. Parry replies, I should like to say that, at the Annual Meeting at Leeds in 1880, after papers had been read by Mr. Vawser and Mr. Hewson, I ventured, in the discussion, to shadow forth the idea that you were to some extent in this matter to trust to Providence. This was thought at the time a dreadful idea, and brought down upon me some formidable replies from the readers of the papers. I find to-day that, practically, all the speakers who have taken part in the discussion, in one form or another have lugged Providence into the subject.

Mr. PARRY: I must say I am pleased this paper has elicited such a discussion; I expected it would, because I know it is a subject on which great difference of opinion exists. Mr. Spencer asked me to reply to something, but I was quite unable to catch in substance what it was he said. In reply to Mr. Colthurst, I may say I directed special attention to the death-rate in my paper, to show the little effect the works had had upon it. With respect to the remarks of Mr. Buckham, the flushing of the sewers, which requires about 24,000 gallons per day, applied in the manner I have stated, is for the purpose of purifying the drains. There are no obstructions, and the cleansing of them is perfectly satisfactory and very efficiently done in the way I have described. Mr. Hall thought it much better to purify sewers by rainfall than by flushing. My opinion is that the water we put in as it may be required is much better than allowing any quantity of rainfall to go in that may happen to come. I am rather surprised at Mr. Vawser's question, because I hinted in my paper that, if further information is required respecting the Act of Parliament obtained for Reading, I shall be pleased to insert in the paper the clauses of it which relate to the separate system, to be printed in the Proceedings of the Association. I will ask you, Mr. President, to take the opinion of the Meeting whether that should be done?

The PRESIDENT: Do you wish me to put the question now?

Mr. PARRY: If you please.

The President accordingly put it to the Meeting whether the material clauses of the Act should be inserted in the paper; and it was unanimously decided that they should be inserted.

Mr. PARRY: Then I shall be happy to supply them. In the first instance, when sewage sewers had been provided, it was intended that the old sewers should be used for surface water, and that only new sewers for surface water should be laid down where none existed. Thus there has only been a very small district that has had to be drained, and there has been no need to provide a special sewer to carry all to one outfall. There are dozens—at any rate twelve to a score—catchment areas that could be drained into existing watercourses, so that it has really been very easy to do. Mr. Jones refers to certain proceedings in Reading as being generally prejudicial. We, as sanitary engineers, are expected to deal with towns and districts in the country according to their own special circumstances. I have had to deal with Reading as Reading. The Corporation commenced twelve years ago by getting an Act of Parliament to deal with the sewage, and it was intended that only sewage should go to the farm. I was therefore expected to separate the surface water from the sewage, and I have done that. With reference to Mr. Pritchard's remarks, I do not think he has read the paper.

Mr. PRITCHARD: I listened to it when it was being read.

Mr. PARRY: Well, you say that 1,813,000 gallons of water are supplied daily to a population of 42,000. I have said that the town and district included have a population of 50,000.

Mr. PRITCHARD: That does not alter the result much.

Mr. PARRY: But it does. It must make a difference whether 1,813,000 gallons are supplied to 42,000 or 50,000 people.

Mr. PRITCHARD: It makes a difference of about 4 or 5 gallons per head; but about the half-inch rainfall, please?

Mr. PARRY: The rainfall in most parts of the town is already provided for, but I may tell you the principle on which I have calculated the quantity of water to be discharged into the sewers is very nearly as Mr. Lemon has supposed it to be. That is, I have taken the length of the roads by the width of the road, and 50 feet on each side, as sending all that falls upon it. I have taken the remaining area of the district as sending a little more than a quarter of it.

Mr. PRITCHARD: It would have been better expressed in the paper, and would have saved asking the question.

Mr. PARRY: I do not think any one would be in a difficulty about it. The half-inch rainfall is not over the whole area of the town, but only for house depths, paved yards, street surfaces, and so forth. It has been calculated by many of those who have gone into this question, that one-sixth of the rainfall goes into the ground—[Mr. PRITCHARD: Meadow land]—Yes: and one-sixth runs off the surface, and the remainder is immediately evaporated. Mr. Lemon asked about Field's flushing tanks, and, in reply, I say the more any one can employ these flushing apparatus, the better for our sewers. I know these tanks are good, and have known them to work well. At the end of house drains I think they might be usefully applied, and the quantity of water put into the sewers in that way by systematic means I do not think would much interfere with the quantity to be dealt with at the sewage station.

Mr. LEMON: I asked whether, where an owner of property has adopted special means of flushing—for instance, has put down Field's flushing tanks—the authorities at Reading would compel the owner to put in another drain?

Mr. PARRY: No: the flushing water in such a case must mix with the sewage, but the rainfall must be separated. As to the points raised by Mr. Jerram, I do not see why you should not separate sewage and surface water where you want to separate them. There may be some slops turned down the surface drains, but we cannot help that. There are other provisions made for sink traps for house slops. Colonel Jones's remarks call for no reply from me; he agrees entirely with the separate system. I may say, with reference to the question of expense, that the sum provided for completing the surface-water drainage has not been large—about 8500*l.*

The PRESIDENT: I meant to have asked you, Mr. Parry, whether in your water supply to closets you insist upon 2-gallon flush cisterns? and whether you consider they afford an efficient flush through a house drain, say of 50 feet or more in length? Do you allow of any kind of automatic flush-tank for closets, by which, when the flush is once started, it must all be discharged?

Mr. PARRY: We do not draw a hard-and-fast line. If we found a closet flushed in that way, there would be no objection made, although we have fixed in our regulations that 2-gallon cisterns shall be provided for the prevention of waste.

The PRESIDENT: I want you to give us your opinion whether you think a 2-gallon flush sufficient through a house drain of 50 feet or more?

Mr. PARRY: It is only a 3- or 4-inch pipe, and when the discharge runs instantly through a 4-inch pipe it pretty well cleanses it.

The PRESIDENT: You are in favour of it?

Mr. PARRY: Yes.

The PRESIDENT: I think we have had a very good discussion, though it has taken a rather wide range. I am sure we are very much obliged to Mr. Parry for his interesting paper.

Sections and Schedule in the Reading Corporation Act, 1881, *empowering the Corporation to enforce the separation of Surface Water from Sewage in carrying out the Sewerage and Drainage of the Borough.*

Provisions of Public Health Act 1875 as to drains to apply to drains for combined drainage.

24. Any drain for the drainage by a combined operation of two or more houses or buildings or of premises not within the same curtilage laid or constructed by or at the expense of the owner or owners of such houses buildings or premises before or after the passing of this Act and after application or request in that behalf made to the Corporation by such owner or owners or his or their agent shall not be deemed to have been or to be a sewer within the meaning assigned to the word "sewer" in the Public Health Act 1875 unless and until the Corporation have acquired the same and until the same becomes a sewer it shall throughout its whole extent up to its junction or point of communication with a sewer of the Corporation be deemed to have been and to be a drain to which the provisions of the Public Health Acts with respect to drains extend and apply and the owners of the several premises from which any sewage or surface-water flows directly or indirectly into such drain shall be liable from time to time to maintain and repair the same and in case any such drain be not maintained and repaired to the satisfaction of the Corporation the same shall be deemed to be a nuisance within the meaning of the same term in the Public Health Acts and all the provisions of the said Acts with respect to nuisances shall extend and apply thereto.

As to the maintenance of Sewers not belonging to Corporation.

25. Where any sewer (not being a sewer of the Corporation) is out of repair or dangerous or so foul or in such a state as to be a nuisance or injurious to health such sewer shall be deemed to be a nuisance within the meaning of the same term in the Public Health Acts and all the provisions of the said Acts with respect to nuisances shall extend and apply thereto.

Sewage &c. not to be drained into surface-water

26. No sewage shall be drained into a surface-water sewer of the Corporation or into the gutters in the public streets and no surface-water shall except with the consent in writing of the Corporation be

sewers and surface-water not to be drained into sewage sewers.

drained into any sewage sewer of the Corporation and no surface-water shall be allowed to discharge from a stack-pipe on to a footpath or into a street gutter in any case in which there is a surface-water sewer within one hundred feet of the footpath outlet of such stack-pipe.

Stack-pipes not to be used as ventilating shafts.

27. No water-pipe or stack-pipe for conveying surface-water from any premises shall be used or be permitted to serve or to act as a ventilating shaft to any drain which communicates or which is intended to communicate with any sewage sewer of the Corporation.

Prohibition against emptying cesspools into sewers or drains.

28. No cesspool shall communicate directly or indirectly with any sewer of the Corporation and no cesspool shall be used for the drainage of any premises in any case where there is a sewage sewer of the Corporation within one hundred feet of any part of such premises. No person shall pump place or throw or otherwise cause to run flow or fall into any gutter water channel or catchpit in any street or into any sewer of the Corporation or into any drain connected therewith the contents of any cesspool or other like receptacle for the reception of sewage:

Any person offending against this enactment shall for every such offence be liable to a penalty not exceeding the sum of five pounds and in the case of a continuing offence to a further penalty not exceeding the sum of forty shillings for every day upon which such offence is continued after the day upon which the first penalty is incurred.

Corporation may order drains emptying into improper sewers to be closed.

29. Where sewage from any premises flows through any drain communicating with any surface-water sewer or where the surface-water from any premises flows through any drain into which any sewage flows or into any sewage sewer the Corporation may by written notice require the owner of such premises within a reasonable time specified therein to cause any such drain to empty into any sewer of the Corporation within one hundred feet of such premises and if such notice is not complied with the Corporation may after the expiration of the time specified in such notice do the work required and may recover in a summary way the expenses incurred by them in so doing from such owner or may by order declare the same to be private improvement expenses.

Old drains to be laid open for examination by Surveyor before communicating with sewers.

30. No drain existing at the time of the passing of this Act and then not communicating with a sewer of the Corporation shall be made to communicate with any sewer of the Corporation until the same has been laid open for examination by the Surveyor and he shall certify that such drain may be properly made to communicate with such sewer and if on examination it be found that such drain may be properly made to communicate with such sewer the Surveyor shall cause the ground to be closed and any damage done to be made good as soon as can be and the expense of the works shall be defrayed by the Corporation.

Power of owners &c. to drain into sewers.

31. Except as by this Part of this Act expressly provided the owner or occupier of any premises shall be entitled to cause his drains used for carrying off sewage to empty into the sewage sewers of the Corporation and his drains used for carrying off surface-water to empty

into the surface-water sewers of the Corporation on condition of his giving such notice as may be required by the Corporation of his intention so to do and of complying with the bye-laws or regulations made by the Corporation from time to time in relation thereto and subject to the control of any person who may be appointed by the Corporation to superintend the making of such communications:

The Corporation may from time to time make bye-laws with respect to the making of junctions and communications between such drains as aforesaid and the sewers of the Corporation and with respect to the supply of water for flushing such drains and the water-closets connected therewith and to the notices to be given and the plans sections and descriptions to be made by the Corporation relative to the drainage of premises into the sewers of the Corporation and the charges not exceeding the charges specified in the Second Schedule to this Act annexed to be paid to the Corporation for making the same and the Corporation may from time to time alter or amend or revoke any of such bye-laws and make new bye-laws instead thereof or in addition thereto and may by any bye-laws made pursuant to this Section prescribe the level fall materials place and mode of such junctions and the materials upon which the drains leading to such junctions or communications shall be laid and the joints grids traps and other appliances to be used for the purposes of or in connection with the same and the mode of ventilating such drains or otherwise in relation thereto:

Any person causing a drain used for carrying off sewage to empty into a surface-water sewer of the Corporation or causing a drain used for carrying off surface-water to empty into a sewage sewer of the Corporation or by any other means conveying sewage into a surface-water sewer or conveying surface-water into a sewage sewer or making any communication between any drain and any sewer of the Corporation in contravention of the provisions of this Section shall be liable to a penalty not exceeding twenty pounds and the Corporation may close any communication between a drain and sewer made in contravention of this Section and may recover in a summary manner from the person so offending any expenses incurred by them under this Section.

After communication of drains cesspools to be filled up &c.

32. Where before the making of any communication between the drains of any premises and the sewers of the Corporation there was any cesspool existing upon such premises such cesspool shall immediately after the making of such communication if the Corporation so require be emptied deodorized and filled up with suitable material to the reasonable satisfaction of the Corporation and if such material cannot be obtained such cesspool shall be securely domed or arched over and all means of communication between such cesspool and any sewer of the Corporation or any drain or sewer leading to or communicating with any sewer of the Corporation shall be effectually stopped up to the reasonable satisfaction of the Corporation.

Corporation in certain cases may compel owners &c. of houses to construct drains.

33. If any house whether built before or after the passing of this Act be found without effectual drainage to the reasonable satisfaction of the Corporation the Corporation may by notice in writing require

the owner of such house forthwith or within such reasonable time as may be appointed by the Corporation to render the same effectual and may for such purpose require such owner to construct make and provide all or any of the following drains works and appliances as to them shall seem fit that is to say:

To construct from such house into any sewage sewer of the Corporation within one hundred feet of any part of such house on a lower level than such house or if no such sewage sewer is within the said distance then into such covered cesspool not being under any house as the Corporation direct a covered drain and such branches thereto of such materials of such size at such level and with such fall as shall in the opinion of the Corporation be adequate for the drainage of such house and its several floors or storeys and also of its areas water-closets privies and offices (if any) and for conveying the sewage therefrom into the said sewage sewer cesspool or other place and provide fit and proper sinks and fit and proper syphoned or otherwise trapped inlets and outlets for hindering stench therefrom and fit and proper water supply and water supplying pipes cisterns and apparatus for scouring the same and for causing the same to convey away the sewage and fit and proper traps expanding inlets and other apparatus for hindering the entry of improper substances therein and all other such fit and proper works and arrangements as may appear to the Corporation requisite; and

To construct a separate drain fit and proper for conveying surface-water away from such house emptying into any surface-water sewer of the Corporation within one hundred feet of any part of such house on a lower level than such house or if no such surface-water sewer is within the said distance then into such waste water well or other receptacle as may in the opinion of the Corporation be adequate for the reception of such surface-water; and

To construct and provide all such works and arrangements as may appear to the Corporation requisite to secure the safe and proper working of any drain constructed in pursuance of any order under this Section and to prevent the same from obstructing or otherwise injuring or impeding the action of any sewer into which it may lead as the Corporation may think proper:

And the Corporation may cause any such works to be inspected while in progress and from time to time during their execution may order such reasonable alterations therein additions thereto and abandonment of part or parts thereof as may to the Corporation or their officers appear on the fuller knowledge afforded by the opening of the ground requisite to secure the complete and perfect working of such works and if the owner of such house neglect or refuse during twenty-eight days after the said notice has been delivered to such owner or left at such house to begin to construct any such drain and other works aforesaid or any of them according to the terms of such notice or thereafter fail to carry them on and complete them with all reasonable despatch

or fail to comply with any of the requirements of such notice the Corporation may cause such drain or works to be constructed and made and such requirements to be complied with and may recover the expenses to be incurred thereby from such owner in a summary manner or may by order declare the same to be private improvement expenses.

As to effectual drainage of houses.

34. No house shall be deemed to have effectual drainage within the meaning and for the purposes of the Public Health Acts or this Act:

If the sewage from such house flows through any drain communicating directly or indirectly with any river or with any stream cut canal or watercourse communicating with any river or with any surface-water sewer: or

If the surface-water from such house is not carried away by means of a drain sufficient for such purpose and so constructed that no sewage can flow into such drain and that no water flowing through such drain can pass into any sewage sewer.

Pipes to be disconnected from sewers.

35. The waste pipe from every bath sink or lavatory and from every safe under any bath or water-closet in a building whether erected before or after the passing of this Act and every pipe in such building for carrying off waste water shall be carried through the external wall of such building and shall be constructed so as to discharge in the open air outside such building and (except in the case of warning pipes) above a channel leading into a drain or sewer and every such drain or sewer at the point of communication with such channel shall be trapped in a manner to be approved by the Corporation and the owner of any such building who therein fixes or suffers any such pipe to remain fixed contrary to this enactment shall for every such offence be liable to a penalty not exceeding twenty shillings and to a further penalty not exceeding ten shillings for every day upon which the offence is continued after the day on which the first penalty is incurred Provided that with respect to a building erected before the passing of this Act no such penalty shall be enforced unless default has been made for twenty-one days in complying with a notice from the Corporation requiring the owner of such building to comply with the provisions of this Section.

Penalty on building houses without proper drains.

36. It shall not be lawful to let any newly-erected house or any house which has been pulled down to or below the ground floor and rebuilt until the same is provided with effectual drainage and water supply to the satisfaction of the Corporation and so that the drains shall be available for the drainage of the lowest floor of such house and of its several floors or storeys and also of its areas water-closets privies and offices (if any) which drains shall lead from such house into the sewers of the Corporation or if there are no sewers of the Corporation within one hundred feet of such house then into such covered cesspool within fifty feet of such house as the Corporation may direct and whenever any such house is erected the level of the lowest floor of such house shall be at such a level as to allow of the construction of such drains appliances and other works and apparatus as may be required in order to comply with any enactment bye-law or regulation for the

time being in force and for that purpose the levels shall be taken and determined under the direction of the Corporation:

Any person who causes any new building to be erected or any drain to be constructed or who lets any such building in contravention of this or the last two preceding Sections shall be liable to a penalty not exceeding fifty pounds.

Power for Corporation to authorize inspection of drains privies and cesspools.

37. The Surveyor or any other person from time to time appointed by the Corporation may inspect any drain water-closet privy cesspool or water supply apparatus (except a water supply apparatus of any Railway Company not being apparatus connected with the Waterworks of the Corporation) or sink traps syphons pipes or other works or apparatus connected therewith and for that purpose may at all reasonable times in the daytime after twelve hours' notice in writing has been given to the occupier of the premises to which such drain water-closet privy cesspool or water supply apparatus or other connected works or apparatus as aforesaid is attached or has been left upon the premises or in case of emergency without notice enter himself or with workmen upon any premises and cause the ground other than the ground of any Railway Company used or occupied by their railway stations sidings works or conveniences to be opened wherever such Surveyor or person thinks fit doing as little damage as may be and if any person obstructs or attempts to obstruct or incites any person to obstruct the Surveyor or such person or workmen in the exercise of any of the powers conferred by this Section he shall for every such offence be liable to a penalty not exceeding five pounds Nothing in this Section contained with respect to ground of any Railway Company shall take away lessen restrict or interfere with any power now vested in or exercisable by the Corporation under any of the provisions of any of the Corporation Acts.

Where no default found expenses to be paid by Corporation.

38. If such drain water-closet privy cesspool or water supply apparatus or other connected works and apparatus be found on inspection as aforesaid to be made to the satisfaction of the Corporation and in proper order and condition they shall cause the same to be reinstated and made good as soon as may be and the expenses of examination reinstating and making good such drain water-closet privy cesspool or other works or apparatus as aforesaid shall be defrayed by the Corporation and compensation shall be made by them for all damage or injury done or occasioned by the examination of any such drain water-closet privy cesspool or other works or apparatus as aforesaid.

Where default found Corporation to cause drains &c. to be put into proper condition.

39. If upon such inspection as aforesaid any drain water-closet privy or cesspool or water supply or water supply apparatus appear to be in bad order and condition or to require cleansing alteration or amendment or to be filled up the Corporation shall cause notice in writing to be given to the owner or occupier of the premises upon or in respect of which the inspection was made requiring him forthwith or within such reasonable time as shall be specified in such notice to do the necessary works and if such notice be not complied with by the person to whom it is given the Corporation may if they think fit execute such works and may recover the expenses incurred by them in so doing from the

owner or occupier of the premises in a summary manner or may by order declare the same to be private improvement expenses.

Provision as to filling up cesspools &c.

40. If it appear to the Corporation by the report of their Surveyor or Inspector of Nuisances or Medical Officer of Health that any cesspool used at the passing of this Act as a receptacle for excreta or fæces or for the whole or any part of the drainage of any house or part of a house or any ashpit belonging to any such house or part of a house is so situate or constructed as to be a nuisance or injurious to health or that for sanitary reasons it is desirable that the same should be filled up or removed the Corporation may if they think fit by notice in writing require the owner or occupier of such house or part of a house within a reasonable time to be specified in such notice to cause such cesspool or ashpit to be filled up or removed and any drain communicating with such cesspool to be effectually disconnected destroyed and taken away and in case it appears by such report that any such cesspool or ashpit is used in common by the occupiers of two or more houses or parts of houses such notice for the filling up or removal of such cesspool or ashpit may be served on any one or more of the owners or occupiers of such houses and it shall not be necessary to serve such notice upon all such owners or occupiers.

Other water-closet &c. accommodation to be provided.

41. If by reason of the filling up or removal of any cesspool or the removal of any ashpit under the last preceding Section any house or part of a house would cease to be provided with sufficient water-closet or privy accommodation or with a proper ashpit the Corporation may by the same or another similar notice require the owner of such house or part of a house within a reasonable time therein specified to provide sufficient water-closet or privy accommodation and a proper ashpit or either of them as the case may require and to lay the requisite drain or drains therefrom into any sewage sewer of the Corporation within one hundred feet of such house or if there be no such sewer then into such other place within that distance as the Corporation may direct If any such notice as is mentioned in this and the last preceding Section is not complied with or is not fully complied with the Corporation may at the expiration of the time specified in such notice do any work thereby required to be done which has not been done by the owner and may recover in a summary manner from the owner or if there be more than one owner from the owners in such shares and proportions as shall be apportioned and determined by the Corporation the expenses incurred by them in so doing or may by order declare the same apportioned as aforesaid to be private improvement expenses.

Corporation may agree to make drains at expense of owner.

45. The Corporation may agree with the owner or occupier of any premises that any drain required to be made altered or enlarged by such owner or any part of such drain shall be constructed made altered and enlarged by the Corporation and the cost price of making altering or enlarging such drain and also the cost of preparing the requisite plans and sections for and superintending such works as estimated or certified by the Surveyor of the Corporation shall be paid in advance or repaid by the owner or occupier so agreeing to the Corporation and

in default of payment the Corporation may recover the same from such owner or occupier in a summary manner or may by order declare the same to be private improvement expenses.

Power to Corporation to make drains into sewers at the expense of the owner.

46. Whenever it is necessary to open any part of the road or pavement of any street for the purpose of making or branching any drain into any sewer vested in or authorised to be made by the Corporation the Corporation may in case they think fit so to do make so much and such part of such drain and also may construct so much and such part of the work necessary for branching the same into such sewer as shall be under or in the said street and may require the prepayment of the estimated expenses of such work or may recover the actual expenses incurred in respect thereof from the owner of the premises to which such drain belongs in a summary manner or may by order declare the same to be private improvement expenses.

Houses not to be inhabited until certificate of completion given by Corporation.

51. Every owner of a new building shall before the same shall be inhabited give to the Corporation a notice in writing that the said building and its appurtenances and the drainage and the ventilation of such building are completed and that the drains thereof are sufficiently trapped according to the provisions of the enactments and bye-laws for the time being in force and a demand that the same may be inspected within seven days from the service of such notice and no owner of a new building shall occupy or allow the same to be occupied if he shall have received from the Surveyor within seven days after the service of such notice a notice in writing that such new building is not complete or sufficiently ventilated and fit for habitation or that the drainage thereof is not completed and the drains not sufficiently trapped in accordance with any enactment or bye-law then in force in the Borough (the notice to state in what particulars the building or the ventilation or the drainage is defective) and any owner who shall occupy or allow such new building to be occupied and any person who shall wilfully occupy the same after such last-mentioned notice has been given shall be liable to a penalty not exceeding five pounds and a further penalty not exceeding forty shillings for every day during which such building shall be inhabited until the defects specified in such notice and found to be contrary to any enactment or bye-law then in force in the Borough have been remedied.

Penalty on occupiers refusing execution of Act.

66. In case the occupier of any premises prevents the owner thereof from carrying into effect in respect thereof any notice given by the Corporation under this Act then after notice of this provision given by the owner to the occupier any Justice upon proof thereof may make an order in writing requiring the occupier to permit the owner to execute the works required by such notice to be done and if after the expiration of seven days from the service of such order the occupier continues to refuse to permit the owner to execute the said works such occupier shall for every day during which he so continues to refuse be liable to a penalty not exceeding five pounds and during the continuance of such refusal the owner shall be discharged from any penalties to which he might otherwise have become liable by reason of his default in executing such works.

Right of Appeal in certain cases.

70. Any person deeming himself aggrieved by the order or decision of the Corporation or the Surveyor with respect to any matter mentioned in this Part of this Act other than matters with respect to which any other mode of appeal is prescribed may appeal to the Local Government Board under the provisions of Section 268 of the Public Health Act 1875 and for the purposes of such appeal any decision of the Surveyor shall be deemed to be an order or decision of the Corporation.

SECOND SCHEDULE.

Having reference to works described in Sections 45 *and* 46.

Charges to be paid to the Corporation for making Plans Sections and descriptions relative to drainage of premises into sewers of the Corporation.

In the case of houses or premises where the gross rental is under 15*l.* a year:

For not exceeding two houses . .	7*s.* 6*d.*	for a set of 3 Plans Sections and Descriptions.
For exceeding 2 and not exceeding 4 houses.	10*s.* 0*d.*	„ „
For exceeding 4 and not exceeding 6 houses.	12*s.* 6*d.*	„ „

and 2*s.* 6*d.* additional for every 1 or 2 houses beyond 6.

Where the gross rental is 15*l.* and under 40*l.*:

For 1 or 2 houses	7*s.* 6*d.*	for a set of 3 Plans Sections and Descriptions.

and 2*s.* 6*d.* additional for every house beyond 2.

Where the gross rental is 40*l.* or upwards:

For a single house	10*s.* 0*d.*	for a set of 3 Plans Sections and Descriptions.

and 5*s.* for every additional house.

THE SUPPLY OF ELECTRICITY BY LOCAL AUTHORITIES.

By KILLINGWORTH HEDGES, Assoc. M. Inst. C.E.,
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The Electric Lighting Act, which dates from the 18th August, 1882, has had the effect of causing considerable stir among those interested in the development of the new light, and others who look with anxiety on any public improvement which is likely to affect the pockets of the ratepayers.

The provisions of the Electric Lighting Act are now well known, but it may be pointed out, that, with a view to prevent the establishment of a monopoly, the same rights are given to local authorities to lay down the necessary works and to supply their own electricity, as to a company who wish to act as contractors.

In consequence of this power, seventy-seven applications for provisional orders were made at the end of last year by various corporations, local boards, vestries, burghs, boroughs, Imperial Commissions, and urban sanitary authorities, each representing the local authority of the district to be lighted.

The question as to whether it would be more advantageous to the public to obtain electricity from the corporation of a town or from a competing company acting as the undertaker for the supply under the Act has doubtless been discussed in each district where an application has been made.

From the many notices of opposition which were lodged against the applications of the contractors, it would appear that either the local authorities do not consider electric lighting is yet sufficiently developed, or object to placing a portion of the district under their control in the hands of an electric company.

Against the plan of the authorities acting as contractors may be advanced, the supposition of future improvements which may take place in the means of generating electricity, and which, if perfected, would render useless the machinery which might have

been purchased at a considerable cost. On the other hand, it must be remembered that according to the Act the maximum charge must now be fixed, to do which, the company will be guided by existing arrangements, so that if the cost of production be cheapened, the price charged by the company need not be so until the expiration of the licence.

Considering the short period of a licence and terms on which it will be granted, it is only fair that the company should derive some profit and should have the benefit of cheapened production. But there are many objections to granting any company free control of the streets, some of which are very noticeable by the action of the existing gas and water companies.

For the purpose of this paper, the author proposes to assume that the local authorities have foreseen a demand for electricity, and wishing to forward the affair as much as possible, have placed the matter in the hands of their engineer to report, and he, anticipating difficulties without some practical tests, suggests a method which is a compromise between those previously mentioned. This is, for the local authorities to undertake the preliminary steps of a supply by laying down the necessary electric mains throughout the section of the town or district it was proposed to light, and by providing a site with adequate buildings for the generating station.

This would probably prevent the repetition of annoyances caused by contracting companies having access to the streets; as the mains would be led from the site deemed most suitable for the generating station and might be handed over to the contractors for the experimental or permanent lighting. Its gauge would be calculated to take sufficient current to supply the district at a determined electrical pressure, so as to give the required electromotive force without risk from fire or danger to life.

As the area of the conducting mains is determined to suit the current to be employed, it would not be possible to use the most economical size of cable, if experiments were to be made with several different systems. To provide for this contingency an extra main might be laid down and coupled to another so as to increase the area if required for an experiment. Assuming that the first steps towards initiating a supply of electricity are to be taken by the district authorities, the author proposes in rotation to deal in this paper with some of the subjects which would come most prominently before the engineer in charge.

The Generating Station.

The first point to decide on would be the position of the station where the dynamos or electric current generators and their motors would be fixed, and from which the electric mains would be distributed.

In the case of a town having sufficient water power available, dynamo machines to utilise this force would be erected with suitable motors as near as convenient to the source of power. The generating station, if water power was used, would hardly be in the centre of the district to be lighted, so that in all probability the length of some of the electric circuits would be more than others. This should be as much as possible avoided, and where a steam-engine is employed as the motor, the situation of the generating station should be as central as possible. The area which can be lighted most advantageously from the source of power has yet to be determined. It has been stated by Sir William Siemens that a radius of a quarter of a mile in every direction from the station would probably be as much as could be economically worked. The power required depends on the number of lights in this area, and, taking Sir William Siemens' estimate for the entire parish of St. James's, London, over 33,000 horse-power would be necessary. This is probably a very high estimate, and is based on a lower efficiency per horse-power than is now practicable; besides, in any district it is not the least probable that all the householders will speedily adopt the electric light, and doubtless there will be a considerable number who will refuse it altogether. This would make it very difficult to establish a station to serve a special area, and, as there is no difficulty in leading electric mains for a considerable distance, it would be better in proportioning such mains to assume that they are to be laid in the most important part of the area to be lighted.

The Electric Lighting Act allows of this in the clause relating to the choice of area of supply. "A fair area is to be included under Schedule A, in which the undertakers may make an experiment, and if they find this experiment not sufficiently remunerative to induce them to extend operations, they may confine themselves to this." At the same time it is proposed that a further area—Schedule B—be granted, to which the undertakers, after feeling their way by the first experiment, may extend their operations by degrees, subject to the right of the local authority, or where the

local authority are themselves the undertakers, of certain inhabitants, who may at any time require the undertakers to extend their operations over any part of such area.

The fuel required would be a serious item, so that means should be taken to secure a low rate of transport by fixing the position of the station near the siding of a railway or on the banks of a canal.

In large cities like London there would be some difficulty, and a site sufficiently central would cause an enormous outlay for purchase of land. This was partly overcome in the installation of the Edison light at New York, by sinking considerable depth below the surface of the street, and fixing the engine and boilers in a sub-basement, somewhat similar to the position of the engines on board ship. Sir William Siemens proposes to utilise the area of the public squares, which would be excavated to a depth of about 25 feet, and arched over to the present ground level. In the covered space would be fixed the engines, boilers, and dynamos, the only erection above the surface being the chimney, which would be of ornamental design, and combined with ventilating arrangements for the subterranean chamber.

The Electric Mains.

Although it is quite possible to use, as in telegraphy, the earth as the return conductor, it is far better to have two cables; one starting from the machines being called the *positive*, and that returning to them the *negative*.

Electricity for lighting purposes can be transmitted by wires in the same manner as those now used for telegraphy, which are carried either above ground or underneath. In some cases the return current may be made by a wire in connection with the earth, but the use of earth returns, though not prescribed by the clauses of the Order, requires the special sanction of the Board of Trade.

For temporary purposes, electric light wires may be also taken overhead, but as copper has a far less breaking strain than iron, the spans should be much shorter, or an extra wire used for a support.

A very excellent wire has lately been introduced for multiplex telegraphy in the United States. It consists of a steel wire round which copper is electrically deposited to the required section. It

thus gives great strength with the high conductivity of a copper wire.

Overhead Wires.

At present the legislation as regards overhead wires is not at all clear, and from the continual increase of such wires for telephone purposes the introduction of electric light wires would constitute an element of danger; where such wires have been erected without opposition from the local authorities, it is a question whether they can now interfere in the matter. In the case of electric light wires, if such are likely to be dangerous, local authorities should have summary jurisdiction, and it is very necessary to see that in the hurry to push forward the work of distributing electricity overhead wires are not fixed so as to be prejudicial to workmen engaged in house repairs. As a general rule, all overhead wires should be coated with an insulating material wherever they are likely to be touched or may come in contact with any portion of the building; they should also never be less than 7 feet clear from any part of the roof, and never approach or even cross any wires used for telegraphy or telephones.

As the cable such as would be used from a main generating station would be of considerable size, it is not probable that overhead wires will be employed to any great extent, and the second plan, namely, that of carrying the wires underground, will be generally adopted.

Underground Mains.

A subway probably offers the easiest mode of laying electric mains, and affords a means of access to them at all times.

Only large cities have subways, and these generally are confined to the principal thoroughfares, but if such can be used, the cables would be suspended from the top or sides by means of a strong form of telegraphic insulator. In places where no such provision exists, tubes, either of metal or stoneware, must be fixed of such a size as to allow plenty of clearance to enable the cable to be dragged through.

Several special kinds have been devised, and some, where the tube is divided into two halves, enable the positive cable to be carried in a separate chamber from the negative. The size of the tubes varies according to the number of wires to be carried; for instance,

a tube 6 inches in diameter will take four cables 1 inch in diameter each, and allow for hauling out. At suitable intervals, boxes must be provided where the connections to the houses can be made: that is to say, the cables, both positive and negative, are bared and a smaller cable soldered or clamped on to each so as to form a service line or branch to the consumer, on a continuation of which the incandescent lamps are fixed in what is called the "parallel system."

It will not, however, be necessary to always have a box at each house, as the branch wire can be large enough to supply a group of houses by means of smaller branches. At each point of junction with the main circuit a "switch" should be fixed in order to shut off the current at will, also a "fusible plug," which is a piece of metal so proportioned, that in the event of an excess current being turned on, the increase of temperature melts the fusible plug, and prevents the wires from becoming dangerously over-heated. A plug similar to this will have to be fixed at one end of the wires leading to each house, so as to not only afford a safeguard against increased current being turned into the house, but also to prevent the inhabitants acquiring more electrical current than has been contracted for.

The great difficulty to contend with in underground wires is the leakage of electricity due to water collecting in the pipes. A question thus arises as to whether it is better to lay the mains in water-tight pipes or to simply protect them in such a manner that they shall be fixed as it were in a drain which would conduct all water away. If a water-tight pipe is required it should always be caulked at the joints, and laid with a fall towards the connecting boxes, which may be open at the bottom and connected with a drain.

Water is decidedly the *bête noire* of the electrical engineer; not only does it cause leakage of current, but also in the case of two positive and negative mains being laid close together, water touching two unprotected parts would be sufficient to establish an arc, and speedily destroy the current. For this reason the so-called fire-proof materials are to be avoided as the covering for the mains. Although their electric insulation may be good, the ease with which they are affected by damp would speedily render them unserviceable. All underground mains should therefore have a good covering of guttapercha or some equally good moisture-resisting insulator.

Underground pipes are being dispensed with altogether in the mains laid by the Swan United Company. The mains are simply uncovered stranded wires covered with bitumen and placed in the centre of wood frames, which are filled in with asphalte. The branches are insulated wires fixed in grooves cut with solid planks, which are of sufficient thickness to allow of the wires resting well in the grooves and being permanently fixed in them by means of hot tar or pitch. Suitable junction boxes are provided at intervals in the form of pillars of cast iron, kept either by the side of the curb, as the sanitary boxes now in use, or close to the wall. Into these all the mains are led, so that in the event of a fresh house connection having to be made it will not be necessary to disturb the street, but only to run a subsidiary wire to the nearest box. The mains themselves are to be laid, wherever possible, in the pavement, so as to be out of the way of the existing gas and water pipes.

Where a new street has to be made, the curb might be utilised so as to contain the mains by making it of cast iron and hollow. Cables coated with a thick envelope of lead are also supplied, and, according to the inventors, can be laid directly in the earth. These cables are not to be recommended except on private property, as this would be very liable to be destroyed by accident, and after a time the lead would be subject to corrosion.

The arrangement of the mains and service lines are shown in the accompanying plan, Fig. 1, which illustrates the streets adjoining the Victoria district generating station of the Swan United Company. The main cables are shown at M, the line of the curb stones C, and the service mains to houses S. The round black circles are the distributing boxes, and the small square ones the testing boxes. The generating station is shown at G, connected with the railway, R. The distributing boxes, one of which is shown at Fig. 2, consist of round pillars of cast iron, about 3 feet 6 inches high by 20 inches diameter. Inside are a number of connectors uniting the service mains to the main cable, each connection being made through a switch and a duplex Fusible Cut Out on the author's plan, which admits of a second fuse being brought into action should one become melted.

The plan of keeping these connections above ground is preferable to that of Edison's, which may be interfered with by water collecting in the boxes.

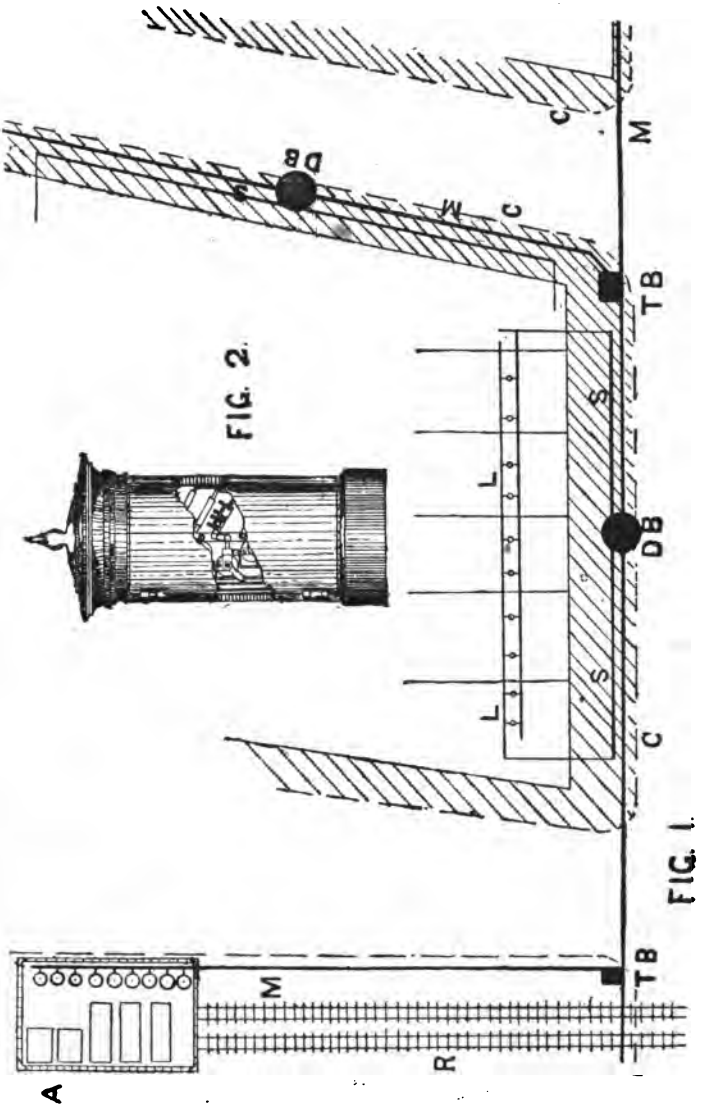


FIG. 2.

FIG. 1.

The Size of the Mains.

The area of the conductor depends greatly on the distance to be traversed before the electricity is used, the object being not to allow the resistance of the exterior circuit to increase beyond a certain extent, which is fixed for each particular system.

If too small a conductor is used, a considerable amount of power is wasted in heating it; if too large, an outlay for copper is sunk: so that a mean has to be struck, which has the object of making the loss as low as possible.

Let us suppose a generating station has been erected containing motive power equal to 1500 horse-power, allowing each incandescent lamp to absorb one-eighth of a horse-power, which is considerably more than is actually the case; this generative force will enable us to work 12,000 lamps, say of 20 candle-power each. The ordinary Swan lamps require 1·4 ampères of electric current, so the total amount to be taken by the mains will be 16,800 ampères.

The following table gives the weight and resistance per 100

Pure Copper.

B. W. G. No.	Area square inches.	At 1000 Amps. per square inch.	Resistance.	
			Ohms per 100 yards.	Ohms per mile.
1	·07068	70·68	·0344	·6065
2	·06334	63·34	·0384	·6771
3	·05268	52·68	·0462	·8135
4	·04448	44·48	·0563	·9919
5	·03801	38·01	·0640	1·1278
6	·03236	32·36	·0752	1·3248
7	·02544	25·44	·0957	1·6843
8	·02138	21·38	·1139	2·0048
9	·01720	17·20	·1415	2·4916
10	·014102	14·10	·1727	3·0397
11	·011309	11·30	·2153	3·7905
12	·009331	9·331	·2610	4·5936
13	·007088	7·08	·3435	6·0477
14	·005410	5·41	·4509	7·9358
15	·004071	4·07	·5976	10·5288
16	·0033183	3·31	·7340	12·9181
17	·002642	2·64	·9652	16·9889
18	·001885	1·88	1·2915	22·7315
19	·001385	1·38	1·7580	30·9403
20	·000962	·96	2·5314	44·5532
21	·000804	·80	2·9713	52·2963
22	·000616	·61	3·9555	69·6168
23	·000491	·49	4·9617	87·3259

yards and per mile, also the current in ampères which can be safely carried per 1000 ampères per square inch of section of pure copper wire. As commercial copper is seldom higher than 96 per cent. conductivity, allowance must be made in calculating the resistance. The rule in the provisional order as to the maximum current which can be safely taken by any pure copper wire allows of a greater amount of current to be passed through, providing the current does not exceed 10 ampères.

The following is a useful formula, which, however, gives a rather higher amount than 2000 ampères per square inch of section, which is the maximum allowed in the Orders:—

$$C^2 = \frac{W}{R} \times 8{\cdot}05;$$

Where C = current safely carried by copper wire of 96 per cent. conductivity; W = weight of the copper wire = 0·32 lb. per cubic inch; R = resistance.

A single strand of No. 3 copper ·259 diameter wire one mile long has a resistance of ·8566 ohms, and the current carried is 100 ampères. Although a cable made of 19 such strands could be made, it would be far more convenient to have three cables, each composed of seven strands, making 21 in all, which would safely carry a current of 2100 ampères. To comply with the *Order* twice this number of cables would be required.

The resistance of each of these cables would not be more than ·1222 ohms per mile;* the first cost would be considerable, but it must be remembered that, unlike the iron pipes of gas and water, the value of copper is little depreciated by use, so that in the event of a larger main being substituted, or the project abandoned the break-up value would not be very far short of the original cost. The price of copper varies with the price of Chili bars, the current quotations for which are published daily. It may be said to average 88*l.* per ton, which brings the cost of No. 3 gauge wire to about 47*l.* per mile.

Motors at the Generating Station.

In many cases, no water power will be available, and it will be necessary to erect steam-engines and boilers to act as motors for the electric machines.

* The Ohm is the unit of Resistance.

Where sufficient space can be obtained, the style of engine best adapted for a permanent installation is the horizontal compound condensing engine, of which there are several varieties. It will be sufficient for the objects of this paper to state that, as an electric light engine has to work for a considerable time without stopping, it must have ample bearing surfaces and efficient means of lubricating same. Either surface or jet condensers may be used; if the former, in some cases it might be possible to make use of the water supply of the town for the purpose of condensing.

Engines of this description are specified by the makers to give an indicated horse-power under 2 lb. of coal consumed, in fact it is quite possible to obtain an indicated horse-power for 1½ lb. using 14 to 15 lb. of feed water per hour; a certain reserve of power is necessary, so that if for an installation of 20,000 lights, six engines, each of 325 indicated horse-power, were used, a seventh should be kept in reserve. The whole of these engines would be arranged so as to drive on to a line of counter-shafting in such a manner that any one could be stopped without affecting the others.

The usual plan is to transmit the power by means of either belting or rope gearing; in both cases allowance must be made for the wear of these, which cannot be worked when there is any chance of their breaking.

Where first cost is not a special object, a spur wheel gearing into a pinion with wooden teeth would probably be cheaper in the end.

In the installations on the Edison system, high-pressure engines coupled direct to the dynamo are used, but although great economy in space is secured, the chances of a breakdown are increased.

Boilers.

Compound condensing engines give the best results with boilers of the Lancashire or Elephant type, but if steam is to be got up quickly, locomotive boilers may be used, or the water-tube boilers, —of which there are numerous types—more or less similar to those employed at the Edison installations. A spare boiler should always be erected for every six working, and each of these should be of such dimensions that they can keep steam easily without forcing, so that in the event of one of the boilers being disabled the others will be able to make sufficient steam. The extra boiler is for the purpose of being substituted for any of the others it is necessary to clean.

The approximate cost of an installation of 2000 indicated horse-power would be—

	£
Six 100 horse-power nominal compound condensing engines, erected at 1600*l.* each	9,600
One in reserve	1,600
Nine tubular Elephant boilers, at 400*l.* each	3,600
Two in reserve	800
Boiler setting and foundations for engines, and ..	
Steam pipes, connections, gauges, &c.	1,000
	£16,600

If a surface condenser be used, an extra sum must be added for the metal tubes.

Dynamos.

Although the electric machines would not be erected under the proposed scheme at the expense of the authorities, some provision must be made for them.

A good plan is to fix strong battens into a concrete foundation in such a manner that two battens are bolted together so as to leave a space through which a holding-down bolt can slide. Each dynamo will rest on two iron transverse pieces resting on these battens, and arranged so as to give lateral movement, while the dynamo and transverse pieces can be fixed in any position on the battens to allow for the tightening of the belts.

Horizontal machines have, as a rule, their centre of gravity near the ground, so do not require any holding-down bolts, but those with the magnets in a vertical direction must be firmly secured.

The lowest cost of 1000-light dynamos may be taken at 750*l.* for 1200 lamps, but as soon as a demand is established a very considerable reduction may be expected.

The cost would be—

	£
Twelve dynamos	9000
One spare ditto	750
Foundations and fixing same	800
	£10550

Speed Regulators.

It is hardly necessary to point out the absolute necessity of having an efficient governor on the engine, so that its speed may not be altered by the work it is called on to perform.

For large engines there are several well-known types of efficient governors; they are all, however, more or less complicated, and the author will pass by them to describe an hydraulic governor, specially devised for electric light engines, which has the merit of being cheap and simple.

It consists of a small centrifugal pump driven by gearing from the main shaft of each engine, arranged so as to deliver a column of water against a weighted piston which is directly attached either to the throttle or expansion valve of the engine.

As the quantity of water delivered varies in proportion to the speed, a very delicate regulation may be maintained by more or less closing the mouth of the delivery pipe. The water is discharged into a small cistern, whence it is led back to the suction of the pump. This governor is being largely used in France for electric light installations, and with very satisfactory results.

Secondary Storage Batteries.

These batteries—often wrongly termed accumulators—act as magazines of electricity which can be drawn on when required; they are destined to play a very important part in the electric lighting of the future.

Although the success of the Edison system in London and New York, where no batteries are used, is often quoted as a reason why their use is unnecessary, it is impossible to economically maintain a constant supply of electricity without their use. Although various forms of batteries have been shown at work, all have failed when put into practical requisition long before the time given by the inventors.

The objection made to the use of secondary batteries is that, first, they do not last, but have to be frequently renewed, and, secondly, that they cost too much.

The first complaint is one which still creates a difficulty to their adoption, one of the causes of which is by local action taking place on the oxygen or positive plates, which causes the peroxide of lead already formed on the plate to be reduced to a lower state of oxidation, and the lead backing supporting it to be gradually oxidised and eaten away. The second drawback, that of cost, is already partly remedied, and will be more so when batteries are put in the market at a price per cwt. unburdened with patents of very questionable value. Minor details, such as suitable connections and jars that

will not leak, have yet to be improved, but given a demand, there should be no difficulty in manufacturing an article of which the cost of renewal would be compensated for by its practical use.

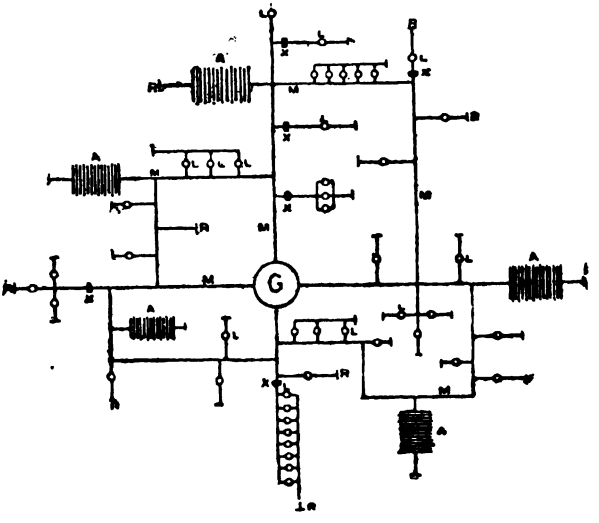
The improvements of Dr. Muirhead and Mr. Brush, which briefly may be said to consist in the method of forming the oxide on the lead plates before these are combined as batteries, will enable them to be constructed much cheaper.

With secondary batteries the engines would not be kept running at all at night, the batteries themselves having been previously charged by what might be termed excess current from the generators during the day over and above what has been drawn for supply of the town or district. In any case, batteries of the present type would have to be fixed at the generating station, as from their bulk they would not be suitable for introduction into ordinary houses.

Mr. Lane Fox has a complete system of electrical distribution in which secondary batteries play a very important part. Fig. III.

The chief points of the system is the use of a generator in a

FIG. 3.



G Generating station. A Accumulators (secondary batteries). R Returns.
M Mains or conductors. L o Lamps. X Meters.

central position, from one pole of which insulated conductors or mains are led to the several points where the electric energy is to

be utilised, being branched and sub-branched as much as required, and thence back to the other pole of the generator by an uninsulated conductor, such as the gas or water pipes. At certain points, storage or secondary batteries are set up in connection, on one hand, with the mains, sub-mains, and branches, as the exigencies of the case may require, and on the other, with the return conductor.

The combination of generators, circuit and storage batteries is such that when the current from the generators falls below the demands made on it from the various outlets to the mains at which its energy is utilised, the deficiency is made up from the storage batteries, which act in unison to supply the requisite quantity of energy. On the other hand, when the current from the generator exceeds in point of quantity the demands upon it at the various outlets, the excess goes to charge the storage batteries and to create a reserve to be called upon in case of need.

Mode of Supply.

Two systems by which electricity may be supplied to consumers are mentioned in the model provisional orders, although any other system may be used when approved of by the Board of Trade.

1st. The Parallel system, which is the one used by the Swan Electric Light Company, the Edison, and others. In this system the electricity used by the consumers is drawn off from a double series of mains, known as the positive and negative, connection being made to each of these by the service lines, the lamps being bridged across a continuation of these, thus forming a series of parallel circuits.

2nd. The Series system, in which all the lamps are strung in a continuous circuit, the whole current being utilised at various points situated successively, and not divided up for the purpose of utilisation into different parallel circuits which supply different customers.

This system is advocated by the Telegraph Construction and Maintenance Company, who, in order to obviate the total extinction of the lights in a house should anything happen to the circuit, propose to have two circuits connected to different machines for the supply of each house, so that only half the lights in a house could be accidentally extinguished. This method entails greater expense at first, and it is doubtful whether the working economy realised is sufficient to justify its adoption.

Electrical Pressure.

The Order requires a standard pressure to be fixed by the undertakers for every main, the amount of which is to be given to the local authority before electricity is supplied.

In the case of continuous currents it shall not be less than 30 or more than 200 volts. In the case of alternating currents it shall not be less than 50 or more than 100.*

This is a most important clause, and one which not only affects the eccnomical working of any electrical system, but also the safety of consumers using same.

The Parallel system of supply being the one which will first come into general use, for the sake of economy lamps will be used requiring currents of as high an electro-motive force as possible within the Board of Trade limits of 200 volts.

The Swan Company propose to use lamps of 160 volts, having filaments of 360 Ohms resistance hot, and taking only ·44 ampères of current, as against the old-fashion 40-volt lamps, having a resisttance of 30 ohms, now requiring 1·33 ampères of currents.

The most economical pressure has yet to be determined. In the author's opinion these new lamps, which may be termed "high pressure," will be very bad for the consumer, as on account of the extreme delicacy of the filament they are very liable to be damaged.

The principal object of using these high resistance lamps is to reduce the weight of copper in the mains. Thus the 160-volt lamp above mentioned requires only one-sixteenth of the weight of copper in the main that the 40-volt lamp does.

The work of the undertakers ends on a pair of poles being introduced into the premises of the consumer, the positive and negative poles being not less than 3 inches apart. No more than 50 ampères may be supplied from one pair of poles, and if more is desired, the supply is to be divided and given by more than one pair of poles.

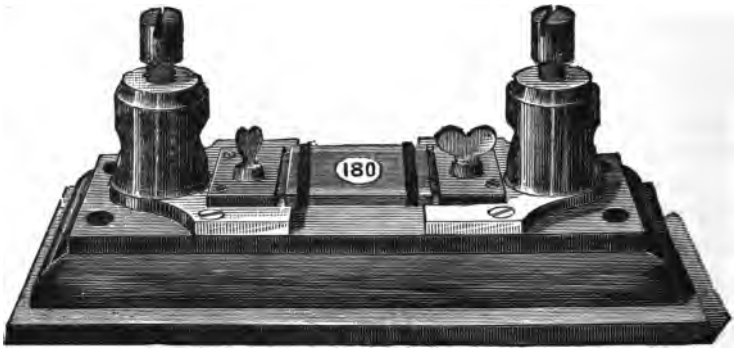
A fusible plug or connection has also to be inserted in a distributing box, or in such point in the service line that it is easily accessible, and arranged so that the fusible portion shall be melted on the current attaining 50 per cent. of the maximum current which such service line is intended to supply.

* *Note that Volt is the unit expressing electro-motive-force or potential.*

This large margin of 50 per cent. will be reduced by the undertakers for their own protection, as this safety plug is of the greatest use to prevent electricity being fraudulently taken by the consumer, by attaching electrical connections to the two poles before they are joined on to the meter.

Some fusible safety plugs designed by the author were shown which will carry with perfect safety 95 per cent. of the entire current they are arranged to work with (Fig. IV.). The maxi-

FIG. 4.



mum current which could be abstracted would therefore be only 5 per cent., which would not be worth while to steal..

A suitable contact breaker or switch will have to be fixed at some point in the service main for the purpose of disconnecting the premises. In the event of distributing boxes being used, this would be fixed in them, and would have an extra terminal to enable an instrument to be fixed for the purpose of testing the current or checking the accuracy of the consumers' meters.

PRICE FOR SUPPLY.

The draft clauses allow three alternative methods of charging :—

1. By the quantity of energy contained in the supply.
2. By the actual quantity of electricity so supplied.
3. By the number of hours during which the supply of electricity is actually used by the consumer and the maximum current which he has required to be supplied.

For plan No. 1 an energy or work meter would have to be

fixed, but until power is contracted for as well as electricity for lighting purposes, this plan would not be generally applied.

Such meters are made, but as they require a clock or some other time recorder, at present they are too complicated to come into general use.

Plan No. 2 is the one which has been put forward in several provisional Orders where the energy of a current of 1000 ampères with the electro-motive force of one volt flowing during one hour is taken to be the unit of current. In other words this may be stated 1000 volt-ampère hours, or the supply of 22·2 ampères, at the electro-motive force of 45 volts for one hour.

The term for unit of quantity is the coulomb, which is the work done by the current of an ampère flowing for one second. An ampère hour is therefore equal to 3600 coulombs, and the unit above referred to would equal 3,600,000 volt coulombs. Therefore the dials of the meters would be divided into divisions, each of which would represent so many coulombs of electricity instead of the well-known 1000 cubic feet of gas.

Quantity meters as constructed at the present time may be divided into two classes,—electrolytic, or those in which the energy of a certain portion of the current is caused to deposit metal on a plate which can be weighed from time to time; and mechanical meters, which record by means of a revolving apparatus actuated by the current.

Neither of these meters are considered satisfactory, so that a power is given to the undertakers to charge for the present by the third plan, which is by the amount of electricity contracted for and supplied for a given time.

This plan, although favourable enough to merchants, and owners of large premises which are required to be lighted for a given time, is not a very satisfactory one for the general public, who cannot tell what quantity of electricity they may occasionally require, and therefore must content themselves with the amount necessary for ordinary daily use.

If the last plan is employed, an improvement suggests itself, which would enable the amount contracted for to be doubled or trebled at will by the consumer. If the undertakers would lay say three service mains, which, by a simple apparatus, could be used either singly or connected together, the position of the connecting apparatus each day might be afterwards verified by means

of an apparatus similar to the bell punch used in checking the receipts of tramway conductors.

Having introduced the electric mains into the houses of the consumers, the duties of the undertakers end as far as they can be discussed in this paper. Several important points, as regards the time and duration of the supply, require to be arranged, also the question of the charge which the undertakers shall be entitled to make to the consumer for the energy supplied.

In the foregoing remarks the incandescent system is supposed to have been adopted throughout. Should it be determined to light the streets, squares, and public buildings, the arc system would be far the most economical, although it is very questionable as to whether for street lighting, gas is not still the best illuminant. It would be, in any case, advisable to lay a separate main for furnishing the electric current to the street lights and other public lamps which would require to be lighted and extinguished at a fixed time throughout the year.

The saving of the wages of the traditional lamp-lighter would be one economical step towards bringing the price of electricity to that of its cheapened rival,—gas.

DISCUSSION.

Mr. Thos. H. Blakesley: Mr. President and Gentlemen,—It is only by your courtesy that I am present at this meeting, being unfortunately hitherto a stranger to this Association. I have therefore to ask your indulgence, in venturing to address to you a few remarks upon the important questions touched upon in Mr. Hedges' interesting paper. It is a very important thing that the local authorities generally should be thoroughly well informed of the action of the Legislature which has taken place recently. I suppose most of those present have had their attention called to this subject. It has been my duty to examine minutely the Provisional Orders sought by the companies in the matter of electric supply, and therefore, as I have had to study the details, perhaps what I have to say may be of interest to the Members of this Association. The Act of Parliament on which all future electric lighting on a general system is to depend, is in many respects very disappointing, but the action of the Board of Trade, in whose hands the bill became law, and who have been invested by it

with so many functions and duties, has been in the discharge of those functions and duties, for the protection of the public, more disappointing still. We have now only the local authorities to stand between us and the operations of the Electric Lighting Companies, and thus it will be to the Members of the Association of Municipal Engineers that we must ultimately trust. Do not imagine that, in making these remarks, I am in any degree opposed to the general introduction of electricity. It is because I know so well how useful an agent it is, that I am unwilling it should be monopolised, as gas and water have too frequently been, in hands which are certainly not the best. You hear of large public meetings called together to promote the merging of metropolitan affairs in one central authority, while the Board of Trade is busy granting the most extravagant demands of electric companies. I have called the Act disappointing, and I think it will be considered so by those who appreciate all the uses of electricity. It will hardly be believed that out of 3163 questions put to witnesses before the Parliamentary Committee on Electric Lighting, there was no single question upon the subject of alternating currents, their applicability, efficiency, and danger. Compared to direct currents they are dangerous to life, inefficient in action, and limited in applicability, being useless for storage batteries, and comparatively so for conversion into mechanical energy. Yet the companies are to be allowed to supply alternating currents, and so put a serious limit to the applications of electricity. As regards public purposes, the Act in so many words limits the application to lighting. A church, or other public building, may be lighted but must not be ventilated by electricity, and streets may be lighted but not swept by it. For private purposes it is true there are no such direct limitations; but the companies have found means to provide them indirectly. Now, why should they exist? The explanation is, that the companies dread having their power of supply over-taxed, but still wish to skim the cream from a very large area. You must remember that directly we have a proper supply of electricity, mechanical applications of it will swarm. But the companies deny that they seek a monopoly, and assert that other undertakers are free to supply, if they can obtain the powers to do so. I will show you, if you will allow me, one reason why, if this were to take place, it would be to the disadvantage of the public. It is a law of economy in the designing of a conductor, that the sectional area to carry a given current varies as the square root of the hours per day during which

the current flows. Now suppose a company, A, supplies a certain current for the twelve hours of night for lighting purposes. The economical section of its conductor is then fixed by this law. Suppose it is S. Now another company, B, comes and supplies the same current for mechanical purposes during the twelve daylight hours. B must put down another conductor, also of section S, and the public has to pay for the double section 2 S. But if one company were to supply the current for the whole twenty-four hours, the section of the one conductor necessary would not be 2 S, but $\sqrt{2}$ S, or 1·414 S. This would be a saving of 6 in 20, or 30 per cent. on expense of main, besides there being only one system to interfere with the streets. This is a simple case, but one of a general rule, admitting of mathematical demonstration, that economy from a public point of view depends upon the supply of electricity for all purposes being in the same hands; and those hands, in my opinion, should be those of the local authorities. The author of the paper has alluded very significantly to the dangers to the insulation arising from a damp situation. Some striking illustrations of this have taken place in the mine of La Peronière in France, where there is a case of electric transmission of energy for 1200 meters from the pit's mouth, for winding coal tubs. Of course there were many damp situations in this mine, and in them the original insulation did not hold longer than about one month, though it was composed of indiarubber and Chatterton compound. A lead coating, such as has been suggested by Mr. Hedges in his paper, was tried, but did not answer any better. Only after guttapercha was employed was the insulation maintained; and it really seems as if this were the only flexible conductor which will permanently resist the action of damp. I have thought that, on this account, it may be necessary in a town system to fill the pipes or other chambers containing the mains periodically with air, dried artificially over sulphuric acid. The volume required would not be unmanageably large. Returning to legislation, when we come to modes of supply, it is to be observed that the parallel system and series system are both sanctioned, but all regulations as to price and measurement refer to the parallel system, so that the undertakers can escape them by adopting a form of series, e. g. putting every two houses in series with one another. The standard pressure on which the charge to a consumer is based is the electro-motive force, between the junctions of his service lines with the distributing mains. Obviously there can be no standard pressure if the house-

holder has only one service line making junction with the distributing mains. Then there is the question of electric pressure. The lower limit, 30 volts, is quite inadequate for the best and most economical lamps, corresponding in brightness to an ordinary gas jet. The undertakers may make the services of such a resistance as to absorb 2½ per cent. of the energy supplied at the junctions of the mains and series. This is simply for the purpose of selling the energy so absorbed, as it is not really necessary to absorb in the services anything like this amount. I have supposed a case of a house having 30 Edison lamps of about 15 candles each, and have calculated the length of service lines that by this rule, and that relating to safety in services must be employed. It is 100 yards altogether, i. e. 50 yards for each service line, and this with No. 8 Birmingham wire gauge, which would be the smallest allowed under the circumstances. This is clearly far more than the distance from an ordinary house to the kerb. Then I come to the modes of estimating the energy to be charged for; and draw your attention to the third mode under which the undertakers may assume that the whole maximum supply has been taken during the whole time that any has been taken at all. When a man burns only one lamp it may be assumed that during that time he has been drawing his full current. Can anything be more unjust? Professor Fleeming Jenkin described this clause, in his report, as being so monstrous that he imagined some other meaning must be intended than the straightforward one, but he had been unable to discover any other. Of course he could not, for no other was meant. Yet the Board of Trade have introduced this clause unaltered into the Orders. I think I have now said enough to show that local authorities ought to be most careful, even in dealing with the Board of Trade; and I beg to thank you, gentlemen, for the patience with which you have heard me.

Mr. BURSTAL: It seems to me there is a consensus of opinion among the gentlemen who have addressed us. According to their idea, gas and water works are monopolies, unnecessary things. Now I wish to say the gas and water works in this country have been mainly established by companies and not by corporations. Where they have been undertaken by corporations, they have generally been taken over from private companies in a high state of efficiency —taken over for the benefit of the ratepayers, but not established by the ratepayers or their representatives, who had not the necessary commercial enterprise. I stand up for the gas and water

companies, because they have done a great deal for this kingdom; I can say they have done a great deal more at present than electric lighting companies, if we may judge by the Brush shares, which have been nothing at all but a commercial speculation. We have seen them, sir, quoted from 50 to 8½. I do not wish to oppose electricity, but I wish to stand up for gas and water companies, which I think have done their duty. I can say, from the undertakings which I have been connected with in the midland counties —and I see a gentleman present who presides over one of the largest—that they are most efficient, and I do not think that they should be subjected to such attacks. It was said "there are many objections to granting companies free control of the streets." So there are, but how are you to get over it? You must give somebody control, and I don't think it matters much whether you give a person in the employ of the gas company the control. They both dig a hole, and they repair the road again much in the same way. On page 2 Mr. Hedges says, "In the case of a town having sufficient water power available dynamo machines to utilise this force would be erected with suitable motors as near as convenient to the source of power." There may be a few towns in England, and they would be chiefly in the lake district—Cockermouth I have in my mind—with sufficient water power to drive dynamo machines; but there are very few other towns with the requisite power in summer and winter, without constructing large storage reservoirs, and therefore I think the subject of driving dynamo machines by water power in England may be dismissed. In London the engines, boilers, dynamo machines, are to be underground in squares, with only the chimney visible. That would be very pleasant indeed in the centre of Russell Square, and I have no doubt the Duke of Bedford would have something to say about it. I think something more practicable must be suggested before a meeting of engineers can say that the supply of electricity is altogether practicable. I quite agree with what Mr. Blakesley has said respecting one company having the supply of electricity both for lighting and motive power. Of course there should only be one, but the work of one company would be more than double what it would be for the two companies. If one company supplied light from 6 A.M. to 6 P.M., and the other power from 6 A.M. to 6 P.M., of course there would be some people who would want to use power after 6 P.M., and there would be lighting in addition. Therefore, in the winter time especially, the work of one company would be

more than double that of two, one supplying light and the other power. On page 7 Mr. Hedges gives an estimate for six 100 horse-power compound condensing engines at 1600*l*. I wish they could be purchased for that—16*l*. per horse-power; I do not think that any first-class makers would supply engines at that price. If they would, then I am mistaken; my own impression is that the cost would be almost double; I may be wrong, but that is my impression from contracts recently let. I think in all these estimates for electric lighting there is not sufficient margin as to cost. Mr. Hedges puts down nine tubular elephant boilers at 400*l*. each; considering the size of these boilers, I do not think that is sufficient, and I believe they would cost more. There is nothing allowed in Mr. Hedges' estimate for boiler setting, and foundations for engines. The idea that gas companies should allow gas mains to be used for the return of the electric current was rather like adding insult to injury. Gas and water pipes might be used for the purpose, but I hardly think it should be calculated upon. With respect to ventilating buildings and sweeping streets by electricity, that is going very far ahead of where we are. We can secure ventilation now without going to that extent; and as to street sweeping, that may also, at present at all events, be relegated to the regions of absurdity. I do not think either is practical at present. There is nothing in the paper as to the price of electricity and gas, and there Mr. Hedges has steered clear of a question about which there are many difficulties. I have never heard it put down satisfactorily—taking gas at a certain price, and putting down fairly all the cost of electricity. There has always been a *hiatus* somewhere; and I shall be glad if, in his reply, Mr. Hedges can give us some definite information on this subject.

Mr. JERRAM: I should like to say a few words; I have been instructed to report on electric lighting in our district, because we found the gas company supplied us with inferior gas at a large price, and paid a good dividend to the shareholders. It has been owing to gas companies not doing their duty to the community which has led local authorities to take up the matter of electric lighting, and I think it is very proper that local authorities should take up the question. Our experience of gas and water companies told us to beware of allowing electric lighting to become a private monopoly. Mr. Burstal says that men in the employ of a gas company or a local company break up a street and repair it

again, leaving it in much the same way as they found it; but we all know that a gas or water company leaves a street in a much worse state, and that it is often necessary to write to them a great many times before they will do what they ought to have done in the first instance. Take the Strand district, for example; there, the gas and water companies have had the street up in the busiest season of the year, and did the work only in the day time, altogether regardless of the public convenience. It is because the public have not been properly treated by public companies that local authorities are taking this matter up. I saw last week that the Edison light on the Holborn Viaduct has been so successful that they have agreed to continue it again for the same price as gas, with the result that they get about 1¼ times more illumination from electricity than from gas. This has only been published within the last few days, and may be interesting as showing the latest result between electric lighting and gas at the present time. There is no doubt this matter is in its infancy, and it would not be wise for any local authority to give their rights into the hands of any private company, but to take it into their own hands. But hard heads are thinking of this question, and shortly I hope local authorities will be able practically to consider the question of public electric lighting, and so check the disgraceful way in which gas companies have been treating the people of this country.

Mr. JONES: Some of us know so little of this matter that we are rather disposed to hear all that is to be said, and then carry our thoughts home and meditate upon them. There is no doubt it is one of those important things forced upon us at the present day by circumstances; and, as has just been remarked, electric lighting is in its infancy, and it looks like a thriving infant. There is much credit due to it for having stirred up gas companies, for certainly gas lighting during the last two years has been infinitely superior to what it was before. No finer sight can be seen than in Parliament Street; any night, after twelve o'clock, you will see about as fine a specimen of lighting as could possibly be imagined or desired. I suppose it is not the only illustration, and I do not refer to it as being Sugg's or Bray's, but as showing how splendidly an important thoroughfare like Parliament Street can be lighted. As to the relative cost of gas and electricity, I do not know anything about that; but I do know this, that there is very great difficulty in getting at anything like the approximate price of electricity. That problem has not been worked out, and it is

one of the difficulties we have to deal with in advising our Boards on this subject. It is a question which it is very difficult for any non-expert to know much about. The action of the Board of Trade, to my mind, has been rather peculiar; they seem to have given rather an advantage to companies; and my own impression is that the object of one or two of the large companies which seem to be pressing the matter is to get concessions of districts, and trying to make what they can out of them. I think the gas companies and the electrical companies are considering not the ratepayers' pockets but their own. Of course, it is all very well to make a virtue of this, and profess to benefit the public at large, but the public at large, so far as these particular parties are concerned, is their shareholders. However, there is no doubt a great future for electricity, and I hope to see the day when it and gas lighting are worked hand in hand. As far as gas lighting is concerned, I believe it, too, is almost in its infancy, quite as much as electricity. There is still a wide field for gas never thought of before, which is being forced upon the gas companies by the advances made by electricity.

Mr. LEMON: I think Mr. Hedges was very severe on the Board of Trade on this question. Although the Board of Trade has been advised by experts, it was not possible they could foresee all the difficulties which must naturally arise; but there is one thing which we are certainly indebted to the Board for, as representatives of local authorities, and that is, that this is the first time we have had this principle established, that no company can take possession of a town without the local authority having the option of doing the work themselves. When gas and water companies got their Acts of Parliament, the option of doing the work themselves was never given to local authorities. Local authorities, however, are given the option of providing electric lighting, but I must say very few local authorities have availed themselves of it. This is due, as our past President has said, to want of knowledge respecting electric lighting. There is hesitation in adopting it until more is known about it, and until it can at least be ascertained crudely what the cost will be. We can always tell what gas will cost, but I have not been able to ascertain myself what electric lighting will cost. I find, the same as Mr. Burstal, that the estimate put down for electricity is fallacious altogether. I only wish that I could get engines and boilers at the prices Mr. Hedges has put down in his estimate. I always find, if you take ordinary engines and boilers, you will not get much change out of 100*l*.

per horse-power. Mr. Hedges puts down 16*l.* per horse-power, and there are similar sums for boilers and fittings. These things naturally deter local authorities and their advisers from placing very much reliance on the estimates placed before them by the advocates of electric lighting. Until we get something like a correct basis on which we can form an estimate of the probable cost, we, as engineers of local authorities, shall be some time before we advise them to rush into electric lighting, when we can get very good light from gas—I say very good light, because I know cases where gas is even in advance of electric lighting. I think, therefore, we should hesitate in adopting electric lighting until it is more matured.

Mr. PRITCHARD: I desire to say one word on this subject, because I am interested in electric lighting; and in some eight or nine towns where application is being made for Provisional Orders, I have failed to find all that kindness on the part of local authorities which has been spoken of. Whatever the intention of the Board of Trade may be, local authorities have certainly taken every opportunity of protecting themselves, and quite right too. They have the opportunity of availing themselves of the right to construct works, and of the right to purchase works; but, not content with this, they have in many instances endeavoured to make such hard terms as to give encouragement to electric lighting for a few years, and then to purchase the property at a break-up value. That certainly is rather hard. I may say that the subject treated by Mr. Hedges has been not only interesting but highly instructive. I wish just to ask one question of Mr. Hedges, as to the return current. He says, "in some cases the return current may be made by a wire in connection with the earth, but the use of earth returns, though not proscribed by the clauses of the Order, requires the special sanction of the Board of Trade." I wish to ask, what would be the effect on our telegraphic communications if earth currents were permitted?

Mr. HEDGES: I agree with Mr. Blakesley's remarks, with the exception of his objections to the use of alternating currents, but I cannot go with him so far as to condemn alternating currents, as they can be employed for many of the uses electricity will be put to. First make electric lighting popular, and get it used; if there are certain companies which wish to use alternating currents, and get satisfactory results, I would not deny them the power. There is no doubt that alternating currents are more dangerous

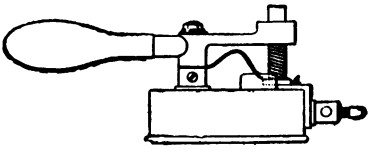
but I think the low alternations allowed by the Board of Trade should be altered, as they might in some cases cause considerable danger. The system of laying the electric mains which I have described has been thoroughly tested by the Swan Company, and I do not see how it can get out of order. It is very necessary to have little resistance in the mains, and I think Mr. Blakesley did well in pointing out the difference between the standard pressure and the pressure consumers have to pay for; but I think it is only right that the companies should have some margin to work on. They are going in for large plant, and for systems which have only been tried in some small way, and they naturally want some protection. I have no doubt the Board of Trade will alter the margin of difference in pressure, as they are able to change any point of detail from time to time, and I should think consumers would soon object to paying for what they have not got. But you must remember that gas companies now make you pay for what you do not consume, because meters at present are anything but reliable. There is a certain amount of windage taking place, which goes into your gas bill, although the gas is not actually burned in your lamps. Mr. Burstal objected to my remarks on the gas and water companies. I raised his anger unintentionally, as I was only speaking of the further extension of similar powers, as in some towns you have gas and water companies, and if there was a third company the difficulty would be increased. Gas and water companies hardly work in harmony now; one comes and takes up the water mains, and then the other follows and takes up the gas mains, and if there was an electric company too, I think it would be rather like chaos. That is the reason I think it would be better to have the mains in the hands of some local authority, who would fix the time at any rate when they were to be taken up, and not allow the whole of the control to be at the will of the contracting company. There was a question raised about towns having the requisite water power to work dynamo machines. I am not prepared to say how many towns have absolutely sufficient water power, but I went down to Northwich, and with the engineer examined the river Weaver, and the power there we found to be quite sufficient. In fact, taking the average level of the water, we found we might get sufficient power direct, but it would be better to have some reserve batteries. At the Falls of the Clyde I understand there is a great deal of power running to waste. There are many other places, too, where power might be obtained, though perhaps not

close to the towns; but what would have to be allowed for in the extra cost of the mains. Then as to the question of the cost of plant, I may say I took the prices given in the paper from the estimate of a large firm of engineers. The estimate I got was a little lower than the figures I have actually put down; I think them perfectly fair; but these engines are of much higher pressure than are usually employed in water works. I am glad to hear from Mr. Jerram that the Edison system is succeeding so well. I had no idea they were continuing their contract at the same price. The Jablochkoff Company, who light the Thames Embankment, say they give the same light for 1½*d.* that, if produced by gas, would cost 3*d.* per hour; and I think the authorities of the Strand district have arranged for this Company to light a large portion of their area at this price. It cannot be said electricity is going back: as one gentleman said—"it is rather a thriving infant"; but you must give it time to grow, and not be too hard upon it at the beginning. Then, as to Mr. Pritchard's question about earth currents. I am not myself in favour of earth returns at all, but they are perfectly practicable. I carried out a large installation for the Mersey Docks in Liverpool, and we used the hydraulic mains there to take the return current; I certainly thought in my plans it would be necessary to couple the flanges together by means of copper strips at the joints where lead had been used, which is a very bad conductor, but the work was pushed forward rapidly, and this was not done, and we found the water was itself a good conductor. I should like to call your attention to a piece of wire on the table which was sent me from America. It is rather interesting, because meetings have been held recently to prevent wires being stretched across our streets. It is steel wire, with copper deposited electrically on the surface, the conductivity is very high, and telephonic messages can be sent through it a thousand miles. If this wire was used across streets it would prevent many accidents, because the steel is very strong, and the copper outside prevents oxidation. The other articles on the table are switches, which will probably be used in some districts; also one of the "cut-outs" mentioned in the paper. Edison uses a bar of lead, but I find a great disadvantage; it is rather uncertain, and when it melts it flies all over the place: so I take a peculiar kind of tin foil, combined with aluminum. Of course, all these fittings are minor details which will be worked out in time; but I think some attention should be paid to them,

because there is a great deal of work to be done almost before the details can be got into shape.

The PRESIDENT: I am sure we are much indebted to Mr. Hedges for his paper. I hope he will not be disappointed at the shortness of the discussion, or its want of practical character. This subject has not yet got within the scope of our practice, though our attention is necessarily turned to it; and when, at some future time, he meets us, we shall probably discuss the question more fully, more exhaustively, and more practically.

Mr. HEDGES: I am very much obliged by the way in which I have been received at this meeting—the first which I have attended, but I hope it will not be the last.



ABINGDON WATER SUPPLY.

By GEO. WINSHIP, Assoc. M. Inst. C.E., Borough Surveyor, Abingdon.

The Abingdon Waterworks were designed and carried out by Messrs. Bailey Denton & Co., the author of this paper acting as resident engineer. The following description of the source of supply and the reservoir has been furnished by Messrs. Denton & Co. at the request of the author:—

"The reservoir, which is situated in the parish of Wootton, about 2½ miles from Abingdon, on the road to Oxford, is constructed in the coral rag and calcareous grit formations of the oolitic series overlying the Oxford clay. At no great distance from the reservoir the Kimmeridge clay is exposed to the surface, while overlying the latter the lower greensand caps the neighbouring hills. Thus, within an area of a few square miles, three distinct formations are exposed to the surface, viz. the lower greensand, the Kimmeridge clay, and the calcareous grit and coral rag, from the rifty caverns of which latter the supply of water to the town of Abingdon is obtained.

"The preliminary operations consisted in sinking a trial shaft some 8 feet square through the rock to a depth of 35 or 40 feet from the surface, and in boring 5 inches diameter some 35 feet further into a stratum of soft soapy clay, into which pipes 4 inches diameter, having screw joints, were driven as the boring proceeded.

"The greater part, if not the whole, of the supply of water, however, was found to spring from a cavern in the rock at the bottom, or just below the bottom of the trial shaft, while very little water was obtained either from the boring below or from the strata above this cavity in the rock.

"During these operations a large quantity of very fine clean sand was pumped out with the water from the aforesaid cavity, so much so that a part of the superincumbent rock caved in, and afterwards caused considerable difficulty when constructing the reservoir.

"While the shaft and boring were proceeding, experimental trials, by continuous pumping by steam power, were made, and

observations noted for the purpose of ascertaining the quantity of water that might be depended on for supplying the town, and further to bring the matter to a still closer test, it was determined to make a cutting about 200 yards in length through very hard rock, entering the trial shaft at a depth of 16 feet from the ground surface.

"In this cutting 9-inch pot-pipes were laid and covered in, by means of which the water rising out of the rock was drawn off continuously for several months and discharged over a gauge-board into a neighbouring watercourse.

"The result of these gaugings, as well as of some other springs in the vicinity, was so far satisfactory as to determine the Council of Abingdon, with the express approval of Mr. I. T. Harrison, the Government Inspector, to construct the service reservoir, and to lay the pipes to supply the town, leaving the question of a larger supply, that it was thought might be obtained by adits in the rock or from other sources, for future consideration, should the necessity arise.

"The reservoir was constructed in the following manner:—An excavation was made for about 60 feet on either side of and embracing the original trial shaft. It was 28 feet deep and about 16 feet wide at the surface, tapering slightly towards the bottom. The rock thus excavated and brought to the surface was afterwards broken in a machine into small pieces about the size of a walnut, and with some fine sand (pumped out with the water as before explained) made into concrete blocks in the proportion of 1 part Portland cement to 4 parts broken material and sand. The making of the blocks and the excavation were carried on at the same time, while an engine and chain pump were perpetually at work keeping down the water.

"As soon as the excavation was got out sufficiently the bottom of the reservoir was put in in concrete, an opening being left round the original trial shaft and bore hole so that the water might rise into the reservoir. The side walls were next built up in concrete blocks backed with ordinary concrete, and the whole domed over from end to end by a semi-arch 13 feet diameter, also in concrete blocks with concrete backing.

"A complete reservoir, capable of holding 125,000 gallons or thereabouts, has thus been formed, into which the water rises from the fissures and hollows of the rocky strata below. The capacity of the reservoir is thus partly artificial and partly natural, inasmuch

as the hollows and fissures aforesaid no doubt afford additional capacity besides the 125,000 gallons of the reservoir itself.

"The level of the bottom of the reservoir is 240 feet above Ordnance datum, the highest ground in or about Abingdon being 200 feet.

"The main pipes to Abingdon from the reservoir are 9 inches diameter; they are laid in the cutting made through the rock before alluded to, and enter the reservoir 10 feet above the bottom. The water is drawn out of the lower part of the reservoir by syphon action.

"This arrangement was determined upon to save the expense of making an extra deep cutting about 600 yards in length, which would otherwise have been necessary to admit of the 9-inch pipes entering the reservoir at the bottom. The shorter leg of the syphon is therefore about 9 feet in length, dipping to the bottom of the reservoir, while the longer leg extends to a distance of 600 yards, or thereabouts, and forms, in fact, part of the supplying main to Abingdon.

"When the water in the reservoir rises, as it generally does at night, up to or above the crown of the syphon, it discharges by gravitation simply, but when it sinks below that level syphon action is called into play to a greater or less degree."

Referring to the excavations, in constructing of the reservoir and laying the pipes, it was found necessary to use both powder and dynamite, but no difficulty to speak of occurred until the portions of rock near the original trial shaft were removed, when a distinct fissure was found, causing a subsidence of the lower rock, over a considerable area, immediately above the bed of rock before alluded to. After a consultation it was decided to sink two cylinders, made of wood, with segmental curbs, and weighed down, while sand and water was excavated and pumped out of the excavation immediately under the side walls of the reservoir. The water was kept at its lowest possible point while these cylinders were being sunk in position; they were then filled solidly with cement concrete and the water allowed to rise and cover them. After allowing time for the consolidation of the concrete, the arches shown upon the plans were sprung from them, and the reservoir completed without further trouble. This part of the work was executed very cleverly by Mr. Henry Potter, the contractor for the works, to whom some credit is justly due.

Supply Pipes, Valves, Etc.

The iron pipes, &c., used were cast by Messrs. Firinstone & Co., and were tested at the foundry up to a pressure of 500 feet; they were all coated in accordance with Dr. Angus Smith's process, and they were jointed with yarn and lead in the usual manner, the sockets of all straight pipes having a groove provided to hold the lead. The pipes were laid in true gradients, with special air valves at all summit levels, as well as at other places. After the pipes, &c., were laid in the trench and jointed, but before the soil was replaced, they were tested by hydraulic pressure in sections varying in length, but seldom more than 100 yards, to suit the various cases, in the following manner. The sections were tested between ordinary sluice valves fixed on the line of piping; and at the upper end of each length a hydrant was fixed. The pipes were then charged with water either from a water cart or from the source of supply, and a removable stand pipe fixed on the hydrant, to which was attached by an ordinary screw connection a small tube, the other end of which was connected to a test pump. The pressure put upon the pipes was never less than 100 lb. to the square inch, and while this pressure was kept up the pipes and joints were thoroughly examined. The result of these testings showed their practical value, as any faulty pipe or unsound joint was immediately discovered and replaced or repaired at the cost of the contractor engaged in laying and jointing the pipes. The length of pipes tested was 12,178 yards, also 53 valves, 77 hydrants, and 4762 joints. The number found defective was 4 pipes, 2 valves, 1 hydrant, and 33 joints. The cost of the whole of the operations was 39*l.*, including the cost of the test pump. In connection with this matter it may be mentioned that a Kennedy's meter fixed on the main pipe on the outskirts of the town enabled a further test of the pipes, joints, &c., to be made; as, upon the completion of the works when the mains were all fully charged with water, the dials of the meter were watched for a period of twelve hours, and no movement was observable during that period, which would have been the case had any water passed from the pipes by leakage in the town. Bateman and Moore's hydrants were fixed throughout, and distances of 100 yards, or oftener, were thought desirable, as a protection against fire to particular buildings. The branch mains are coupled together so that most of the streets can be supplied from either end. There are two outlets into the river Thames for

the purpose of emptying the mains when requisite. A self-recording clock water-gauge is fixed in the waterworks office, and registers the pressure upon the mains every ten minutes. When no water is passing into the town, as at night or early morning, this pressure is equal to the height of water or static pressure in the reservoir.

Meters.

The supply to consumers (which commenced in September 1880), both for domestic and trade purposes, is by meter solely, and was decided upon by the Corporation, after mature deliberation, with the distinct object of preventing waste. The price charged is now 1*s.* per 1000 gallons; but, previous to September last, 1*s.* 6*d.* per 1000 gallons. Sixpence extra per 1000 gallons is charged to consumers outside the limits of the borough. The meters used are known as Tylor's Patent, and are fixed by the Corporation, in a cast-iron box with a movable cover, near to the confines of the properties of the consumers. The lead pipe from the mains to the meters is also laid by the Corporation.

The rent charged to consumers is—

For	½″ meters	6*s.*	per annum.
„	¾″ „	8*s.*	„
„	1″ „	10*s.*	„
„	1¼″ „	11*s.*	„
„	1½″ „	12*s.*	„
„	2″ „	13*s.*	„

The above charge is calculated at the rate of 10 per cent. upon the cost of the meter. In all cases the meters are smaller than the service pipe, that is, ½″ meters would be used for ¾″ service pipes, ¾″ meters for 1″ service pipes, and 1″ meters for 1¼″ service pipes, &c.; the connections on the meters being specially made for this purpose by the makers at the author's suggestion. Since the meters have been in use, two have proved defective. An apparatus for testing the meters has been fixed, and all doubtful meters are taken off and tested; except, however, in the case of the two defective ones mentioned above, they have proved to be correct.

There has been no pressure put upon the inhabitants in any way to compel them to take the water, but there is no doubt that such will be done in the case of many courts and cottages, as already the Medical Officer of Health has reported upon the want of it in numerous instances. Consumers are also allowed to have the water laid on to their premises for drinking purposes, only using their

present pumps in those cases for washing and other purposes. The result of this will be seen in the fact that only 118 connections (at the rate of about 50 per annum) have been made with the mains, supplying 170 houses, and also that the consumption of water, including several cases of waste, does not average more than 5·99 gallons per head per day, assuming that 5 persons occupy each house. The income from these 118 consumers, calculated at the rate of consumption for the quarter ending March 23rd last, would amount to 93*l.* per annum. The rateable value of these 118 consumers, or rather the 170 houses, &c., is 3064*l.*; the income therefore equals a rate of 7¼*d.* in the £ per annum. Taking one special case, in which the water is used for all purposes, the house, &c., is rated at 59*l.* per annum, and occupied by 18 persons, the consumption was 62,000 gallons for the year ending March 25th last, thus being equal to 9·38 gallons per head per day, and a rate of 1*s.* 0½*d.* in the £.

Patent Joints for Lead Pipes, etc.

Tylor's patent joints for connecting meters, stop-taps, ferrules, &c., to lead pipes without solder are exclusively used, and found to answer admirably; in no case have they failed. No skilled labour is required in their use, and they can be made in a few seconds in any weather.

Morris's patent apparatus for drilling mains under pressure is used, and is most satisfactorily applied.

Upon the completion of the whole of the works, but before any connections to private consumers were made, a series of tests were made, with the object of testing in a more accurate manner both the yield of the spring at various depths below the surface of the ground, and also the action of the syphon, in cases of sudden or continued draught upon the spring. The water was made to pass through the Kennedy's meter, and out at one of the outlets in the river Thames. By the aid of the self-recording clock register attached to the meter, which showed the quantity of water passing, and the rate of flow the tests were greatly facilitated. The results were as follows:—

	Gallons per 24 hours.
14 feet below surface of ground	57,600
16 „ „ „	89,000
17 „ „ „	111,000
20 „ „ „	138,666
24 „ „ „	184,000

During the tests no difficulty was experienced with the syphon, nor was it put out of action by any sudden starting or stopping of the flow of water. One test specially made, by suddenly causing the water to flow at the rate of 450 gallons per minute for a period of ten minutes, and then as suddenly stopping the flow, did not affect the working of the syphon.

The regulations under which water will be supplied, and also a form of application for water supply, is appended.

ABINGDON URBAN SANITARY AUTHORITY WATER-WORKS.

Regulations under which Water will be Supplied.

1. Persons requiring a supply of water must fill up, sign, and deliver a form of application, to be obtained at the Borough Surveyor's office.

2. The authority will lay all the communicating pipes within 1 foot of the boundaries of private properties, and will fix a suitable stop-cock to effect disconnection when necessary. All internal pipes and fittings must be executed at the cost of the owner or occupier of the premises subject to the approval of the authority, and to inspection by their officers and servants at such times as they may consider necessary. Existing internal pipes and fittings will likewise be subject to the rules and regulations of the authority, and must, if necessary, be altered so as to conform to their requirements, before connection is made with the main pipes.

3. No house or premises shall, except with the consent of the authority, have more than one communicating pipe.

4. All service pipes should be of lead and of not less than the following weights, viz.:—

½-inch pipes	6 lb.	per lineal	yard.
¾-inch „	9 lb.	„	„
1-inch „	12 lb.	„	„
1¼-inch „	16 lb.	„	„

As a protection against frost the pipes must be laid 2 feet below the surface of the ground, and be properly covered in every exposed situation. All lead joints must be wiped or plumber's joints. If iron pipes be preferred by the consumer they must be of the best high-pressure steam pipe, and be used only above ground, and in such situations as the authority's officers may deem to be safe and unobjectionable.

5. To secure to consumers a sufficient supply when the general

draught is greatest, a cistern to be called the house cistern, holding not less than 25 gallons (increasing in size in proportion to the size of the house), must be provided in each dwelling. This cistern must be absolutely water-tight, properly covered, and placed so as to admit of inspection, and must be provided with a valve ball-tap, with inlet pipe securely fixed to the side thereof. The ball-tap must be so fixed as not to be submerged when the cistern is full, the level of water being so regulated that at such times it shall be 3 inches below the overflow. The overflow which shall partake of the character of a warning pipe, shall be fixed in a position and manner approved by the authority.

6. Water-closets and urinals must in all cases be supplied with water by cisterns separate from the house cisterns which conserve water for use in the kitchen boiler where one exists, or for other domestic purposes.

7. All separate cisterns used for the supply of water-closets and urinals shall be so constructed as to discharge a limited and proper quantity of water each time they are used, and the means adopted for this end must be approved by the authority.

8. Cisterns may be of cast or wrought iron, wooden cisterns must have metallic lining. If lead lining is used it should weigh 5 lb. to the square foot, if the lining be of zinc the minimum weight of the metal should be 16 oz. to the square foot. All cisterns must be properly protected from the influence of the sun, as well as from frost.

9. A tap shall be placed on the communicating pipe supplying the house cistern, in order that water may be drawn for drinking and culinary purposes only, without passing through the cistern.

10. No pipe for the conveyance of water supplied by the authority shall communicate with any cistern, bath, boiler, or other receptacle not approved by the authority, and no bath shall be so constructed that water can flow into and out of it at the same time.

11. No overflow or waste pipe will be allowed in connection with any cistern other than one partaking of the character of a warning pipe, which shall be so placed that the discharge of water may be seen and prevented directly an overflow takes place, and it shall not be moved without the consent of the authority. It is particularly directed that no overflow pipe shall communicate with any sewer, drain, or water-closet.

12. All taps and stop-cocks are to be of approved pattern. There should be a good stop-cock within every house on the communicating pipe near where it enters the premises. None but taps incapable of being too suddenly closed shall be fixed on pipes connected with the mains.

13. Taps to courts or blocks of houses, and all taps outside of buildings, must be self-closing or of some other approved waste-preventing character.

14. No communicating or other pipe shall be laid through or into any sewer, ashpit, sink, manure hole, or any other place where the water conveyed by such pipe might be liable to draw in foul air through a faulty joint or an open tap.

15. All draw taps to water troughs and fountains used in any public place must be of a waste-preventing kind, approved by the authority, and must be only fixed in such places as shall be at all times subject to inspection.

16. A supply of water for domestic purposes does not include a supply of water for any trade or business whatever, or for watering roads, or for use in gardens or greenhouses, or for fountains or any ornamental purposes. Where such supplies are required, the premises must be supplied by meter. The water supplied in any case must not be allowed to run to waste, either wilfully or by neglect, even though it be measured and paid for, nor must it be used for any purpose not agreed for.

17. The authority will provide and fix all meters and will also lay the service pipe to the inlet of the meter, and fix the stop-cock thereon. A rent will be charged for such meters.

18. All works of plumbing and laying service pipes and fixing fittings connected therewith, are to be done by tradesmen certified by the authority, who will be held responsible for the soundness of their work. The names and addresses of such tradesmen so certified will be published by the authority on their water rent papers, or in such other manner as they may consider necessary.

19. Two days' notice must be sent to the Borough Surveyor's office, on forms which will be supplied to certified tradesmen on application, before any alteration or addition is made to any existing pipes and fittings, or when any connection is required to be made with the mains of the authority, and all pipes and apparatus to be laid or fixed for the use of the consumer must be inspected by an officer of the authority before such connection is made.

20. All parties applying for a supply of water, having complied with these requirements, will nevertheless understand that the authority hold themselves free from any liability for damages that may in any way arise in houses or premises by the bursting of pipes or the overflowing of cisterns by reason of frost or from any other cause.

GEORGE WINSHIP,
Borough Surveyor and Waterworks Manager.

BOROUGH SURVEYOR'S OFFICE.

hereby agree to conform to the above regulations, and to do the work in a workmanlike manner to the satisfaction of the Borough Surveyor.

Dated this day of 18

ABINGDON URBAN SANITARY AUTHORITY WATER-WORKS.

APPLICATION FOR WATER SUPPLY.

I, of do hereby agree with the Urban Sanitary Authority for the Borough of Abingdon, to take and receive from them a supply of water by meter, for the under-mentioned premises, viz.:—

from for the term of one whole year, and such further term as the said urban sanitary authority shall think fit, until I give three calendar months' notice in writing, to be addressed to the manager of the said waterworks, and to be delivered at his office in Abingdon, of my intention to discontinue such supply, and I hereby further agree to pay for such supply at the rate of one shilling and sixpence per thousand gallons, and a further quarterly rent of shillings and pence for the meter, the amount to be paid to the collector for the time being of the said urban sanitary authority, by quarterly payments on Lady-day, Mid-summer day, Michaelmas-day, and Christmas-day, in every year, the first quarterly payment thereof to be made on next, subject nevertheless to any further resolutions or regulations of the said urban sanitary authority.

And I further agree that nothing in this agreement shall in any way bind the urban sanitary authority to keep at all times, charged with water, the pipes, or any fire cocks, hydrants, or other apparatus for extinguishing fire, which are now or may hereafter

be attached to any pipes on the said premises in connection with water supplied by the urban sanitary authority, and I hereby declare that the urban sanitary authority shall not incur any liability consequent thereon or incidental thereto, in the event of the said premises being destroyed or damaged by fire, nor any addition to the obligations under which the urban sanitary authority are bound to as consumer of the water.

As witness my hand this day of in the year of our Lord 18 .

Accepted and ordered to be supplied accordingly.

Waterworks Manager.

DISCUSSION.

The Members assembled on Saturday morning, June 30th, and proceeded at once to the Abingdon Waterworks, where they were met by Mr. George Winship, Assoc. M. Inst. C.E., the Borough Surveyor, and conducted over the works.

Mr. WINSHIP said: Commencing with the first portion of the idea, so to speak, a bore-hole was made about the centre of the reservoir in which we are standing, and carried to a depth of about 70 feet until clay was reached, believed to be Kimmeridge or Oxford clay, and the work at that time was therefore abandoned. Some time after, and during the period Mr. J. T. Maland was mayor, and the drainage works being stopped on account of floods, he (Mr. Maland) got the foreman to come up here, and the result was that, instead of continuing the boring, a shaft was sunk, and when a depth of 26 feet was reached, they found an enormous quantity of water. An engine and chain pump were used to pump it up, and the quantity of water was gauged, and just at that time I came to Abingdon. I cannot tell the exact quantity that was found, but there was more than sufficient to supply the town at that depth. Mr. Bailey Denton then recommended a reservoir to be constructed nearer the town, with a fall from the bore-hole into it, so that the water should run into the reservoir by gravitation. At the inquiry the Government Inspector (Mr. J. T. Harrison) thought it was foolish to have a reservoir, as the ground itself was a natural one, and he asked, "Why not syphon the water out?" therefore the idea of a syphon was really first suggested by Mr. Harrison. The

result was that they excavated the rock, and made these concrete blocks with the material in the proportion of one part Portland cement to four parts of broken material and sand, and constructed this small service reservoir. While they were excavating in the centre of the reservoir a portion of the rock gave in, and no doubt this was caused by the previous excavations, as they sometimes used dynamite and sometimes powder, and probably the dynamite caused the rock to split. Cylinders had to be sunk in consequence on either side of the reservoir, and longitudinal arches constructed, and the side walls built upon them. Mr. Denton suggested that we should have a trench cut from the bore-hole, commencing at 15 feet below the surface, in the direction of Abingdon, with just a little fall, and pot-pipes put in, and a gauge-board fixed at the outlet. About 50,000 gallons per day was the minimum gauging, and the maximum quantity was 300,000 gallons during a period of about two years. I suggested another gauge-board should be fixed about 200 yards from here, the total length of the cutting being just over a quarter of a mile, and as that board showed a less quantity by about one-eighth of an inch over a 12-inch gauge-board, that quantity was afterwards picked up and conveyed back here for the purpose of filling the syphon if it should fail. We have at the other end of the syphon a valve, and by closing it and opening this tap in connection with the water picked up, we can fill the syphon. If we get air into the syphon and the water in the reservoir is above the landing on which we are standing, we have simply to open the tap connected to the top of the syphon, and the air will rapidly escape and recharge the syphon. We have no air pump, but simply fill it with water. During the winter the water is generally above the syphon. We are rapidly extending our mains, and we have had several severe tests on the works. We have run for a month below this level to test it, and the result shows that we can work with any level. It has been about a week at this level. We had out in one day last week 149,000 gallons, and should not have known it, but we had one of our engines out of repair upon the sewage farm, and it caused me to examine and ascertain the quantity passing into the town. The next day it was 49,000 gallons. We open the air valve about once a week, but we can always find air in it, however short the time it may be in action. You must understand the syphon is capable of discharging upwards of 300 gallons per minute, but as our draught is nothing approaching that quantity, we have never felt the slightest inconvenience from the use of the syphon.

I think that proves you should always have a syphon large enough to exceed the maximum draught. The spring we met with is sufficient to fill the syphon, and it has now been in action about two years, during which time we have never had to charge it. We have not had any long period of dry weather since these works started, and I should think our greatest draught upon it has been this year. We gauged it for three months last year specially and continuously.

Mr. COULTHURST: With regard to the commercial part. You supply by meter solely, and you cannot collect the water rents until you have registered the meters. Supposing in the interim anybody was to fail, how would you recover? You have to give a quarter's credit.

Mr. WINSHIP: In that case we should have to lose it, but we have no difficulty in collecting the rents.

The Members then returned to Oxford, and a discussion on the works took place in the Council Chamber.

Mr. LEMON said: I think the works we have seen this morning are very interesting. I always consider these small works are perhaps in one sense more interesting than larger ones, because the great difficulty we, as engineers, feel, is how to supply a small town with water at a reasonable cost, and of course with regard to the rateable value of the population. In this case it seems to have been done very successfully. There are some observations I should like to make with reference to the scheme generally. If I understand the paper rightly, the main from the reservoir to the town is also used in some part of it for supplying the town. I think in that case it would be better if there had been an inverted syphon, because it would have checked the air occasionally found in the pipe. As regards the supply of water, I notice that it is extraordinarily small—only six gallons per head—and that the meter system is adopted throughout, not only for trade, but for domestic purposes. We know that is a very unusual circumstance—the introduction of meters in all cases—and I think it is open to some objection. I consider six gallons per head is too small an amount for sanitary purposes. I think a minimum consumption should have been fixed; that is to say, each person should be charged for a certain number of gallons per head, and over and above that amount, so as to check waste, they should be charged by meter. If that were done there would not be the tendency, as there is at the present time in the town of Abingdon, to use such a small proportion

of water—quite out of proportion, in my judgment, to all reasonable requirements for health and proper sanitary arrangements. Then I notice it is made compulsory to use cisterns in houses. In clause 5 of the Regulations it says, "To secure to consumers a sufficient supply when the general draught is greatest, a cistern, to be called the house cistern, holding not less than 25 gallons (increasing in size in proportion to the size of the house) must be provided in each dwelling." According to the test which we made at the flow, I am inclined to say that a house cistern is not required at all, and I think it is exceedingly objectionable. I have a great objection to cisterns; I think they are abominations in most towns, and where you can get a supply direct from the main, by all means do it, and I don't see in this case why it should not be done. Those are most of the notes I have made, Mr. President, and I won't detain the meeting any longer, as I know time is short.

Mr. PARKER: I should like to ask Mr. Winship, seeing that in this case it is proposed to use the inferential meters, if he has tested them with the Kennedy's positive meter. I am inclined to think that meters for domestic purposes are not only a mistake from a sanitary point of view, but it is almost criminal on the part of the Corporation to insist upon them, because persons would abstain from using that amount of water which is essential for flushing closets and for sanitary purposes and so be prejudicial to the drains themselves. I could not tell, like the previous speaker, why this cistern to hold not less than 25 gallons was wanted at all; and then with regard to inferential meters, I could so arrange the stop-tap as to have all the water I required, and not have one gallon recorded by the meter itself. I do not know whether there is a minimum charge made whether the persons consume any water or not, but there should be, or the financial results will be disastrous. I observe that previous to September last the price charged was 1*s.* 6*d.* per 1000 gallons, and now it is 1*s.*, and there would be 6*s.* per annum interest to pay on the rental of the meter itself. I contend that the gross waste of water can be prevented, and without the adoption of meters; all that is required is double chamber cisterns. The consumption is very low. Only thirty-nine houses, as I understand, have been connected with this system, and it has been about two years in operation. I happen to know that at Bridgwater, where the works were constructed by Messrs. Oakley, there were no meters, and at the end of October 1879 — in one

year and nine months—they had put on 1300 houses, representing a gross water rental of 1200*l.* per annum, in that short time. I have no doubt it will be a long time before you can get a sufficient revenue to pay for that outlay under the present arrangement, and I say a constant and unlimited supply can be given without meters at all, as was done really in that case, by seeing that a proper class of fittings are adopted. With regard to authorised plumbers, I am afraid Mr. Winship, like many waterworks managers, will find that a difficult question. I do not know whether there are any who do work and are not authorised, but even if a plumber refuses to become authorised or to subscribe to these rules, if he does his work in a satisfactory manner, I take it that you cannot refuse to pass the work. I object on sanitary grounds to these meters.

Mr. TAYLOR: I should like to know whether Tylor's patent meter was selected after having tried other patent meters, or if they use it because they think it the best; and can the author of the paper give us an analysis of the water?

Mr. GAMBLE: I see in the regulations it says, "No pipe for the conveyance of water supplied by the authority shall communicate with any cistern, bath, boiler, or other receptacle not approved by the authority; and no bath shall be so constructed that water can flow into and out of it at the same time." How would Mr. Winship construct a vat if the tap is not to run? I see a difficulty in that being carried out. Then further on it says, "all taps must be self-closing," but there has been great difficulty experienced in frosty weather with these taps, and some people may not be able to get them to work properly. And clause 16 says, "A supply of water for domestic purposes does not include a supply of water for any trade or business whatever." But it all goes through the meters, and I don't see what it is to do with the authority if the water is used for any other purpose. Looking at it from a business point of view, if they wanted to create a dividend and make it a success financially, they must sell the greatest quantity they could. They also say, "Two days' notice must be given before any alteration or addition is made to any existing pipes and fittings." If connections are made, I hardly see that affects the authorities so much, if every drop of water will pass through the meters. I don't see the utility of these two clauses.

Mr. READ: I agree with Mr. Parker's observations as to these inferential meters. My experience of meters similar to those of Tylor's is, that they register very well as long as they are clean,

and in good order, but they gradually and slowly decrease in the registering until they stop altogether, if they are not well looked after. What we do is to have a rent based upon the rateable value of the house. That is the lowest charge made to the consumer, and when the meter registers in excess of that a charge is made accordingly for the additional quantity.

Mr. VAWSER: The matter we have been called upon to consider to-day refers less to the regulations for the use of water than to the somewhat novel scheme of introducing water into the town of Abingdon. I am glad we shall have some record of this scheme on our books, because it is in its way a very novel scheme indeed. Mr. Pritchard some time ago brought under the notice of the Association a somewhat similar scheme he had laid out for the town of Warwick, and I shall be glad indeed if some arrangement can be made to incorporate with this volume, and in connection with this discussion, some brief details of the work that Mr. Pritchard carried out some years ago at Warwick. There are a number of details in connection with the rules that one would like to discuss, but I think our visit to Abingdon was more for the purpose of seeing the syphon principle than for discussing plumbers' regulations, and I merely refer to them again in order to say that where it is possible to supply an unrestricted quantity of water to the inhabitants it is infinitely better so than where the water must be restricted to a meter service and charged for by meter. Of course there are places where the limited supply of water available would render it necessary to restrict it, and in such a case the Local Board could be excused, but as a principle, the supplying water by meter is very much to be deplored.

Mr. COULTHURST: I understand the cost of the works was something over 9000*l.*, and the present rental for supplying 118 consumers is 93*l.* per annum. I think it is important to see if 1*s.* per 1000 gallons is sufficient to make it remunerative. My own opinion is that it would be far from remunerative, and no doubt the people are told if they are not economical in using the water they will have a heavy bill to pay, and in consequence they do not use a sufficient quantity to ensure cleanliness and proper sanitary precautions. With regard to the connections to the house, I don't know whether you charge from the main to the house, or whether that is put in at the expense of the occupiers. I should like to know what quantity of water is used for other than domestic purposes, street water, and the like. I entirely agree with what has been said by Mr. Lemon

with regard to the nuisance of storage cisterns for domestic supply.

Mr. Downing: I stated before the Members started that they would see some most interesting works, and I have no doubt my prophecy has been fulfilled. I forgot to ask Mr. Winship whether the 4-inch hole through the soapy clay he speaks of still remains open. He says in his paper that nearly the whole of the water was secured from the rock above, and that a small quantity came out of the clay, and I suppose he has not closed the 4-inch hole. I observe he took a wise precaution in leaving the mains open and testing them in lengths, and the advisability was proved by the result. One portion it seems to me had a large proportion of defective joints on so small a main. With regard to the meter question, I may mention that the Abingdon Corporation consulted me in a friendly way through Mr. Winship, when the question was first mooted, and so far as I remember, I told them that it behoved them to be very cautious in adopting a meter system, and I mentioned that at that time I did not know of more than one town in the kingdom that was supplied solely by a meter system. I said the consumption would be somewhere about five gallons per head, and I find from Mr. Winship's paper that it is 5·99. In considering the expense and what should be charged per 1000 gallons, I told them they would not get sufficient revenue from their customers unless they charged 2*s.* 6*d.* per 1000 gallons. The price charged was 1*s.* 6*d.* per 1000 gallons, and now it is 1*s.*, and that seems to me exceptionally low. I did not know until it was mentioned to-day that the cost of the works was 9000*l.*, and from present appearances they will only have a small revenue to cover the expense they have been at. I see the revenue is 93*l.* per annum, and Mr. Winship gives one or two instances of revenue derived from respective houses. I will take one instance where the rateable value is 59*l.*, but that appears somewhat exceptional from the fact that there are eighteen persons in it; their consumption was 62,000 gallons for the year. Perhaps you will excuse me if I take the charges for the water in the city of Oxford, and compare them with those of Abingdon to show the difference. I take our own city because I am more conversant with it. I may mention that Mr. Winship does not in his paper say whether this 5·99 covers the supply of water to closets, but I take it that it does. I take the case of the City of Oxford Waterworks on a rental of 59*l.*, and with two water-closets, our charge for that would be two guineas

per annum; 1*l.* 9*s.* 6*d.* at 6*d.* in the pound on the gross rental, and 10*s.* for the first water-closet, and 2*s.* 6*d.* for the second. But according to Mr. Winship, the charge by meter for 62,000 gallons would be 3*l.* 2*s.*, and with the meter 3*l.* 8*s.* Taking a 20*l.* rental, our charge would be 6*d.* in the pound and 7*s.* for the closet, that would make 17*s.* per annum. Taking five inmates in a house of 20*l.* a year, you would have 11*s.* for your meter consumption and 6*s.* for the rent of meter, which makes 17*s.*, coming to exactly the same as the City charges at the present time. And going lower to a 12*l.* house, our charge would be 6*s.* for the domestic supply, and 4*s.* for the closet, making 10*s.* per annum. In a 12*l.* house it is fair to assume you would still have your average of five inhabitants, and so represented by meter supply the 12*l.* would still be 11*s.* and 6*s.* for meter, which I think very heavy. With regard to cisterns for houses, I agree most positively with the remarks of previous speakers. I think they are absolutely a nuisance for any domestic supply whatever. Whilst engineer in Oxford, I had constant complaints with regard to them, and infinite trouble to contend with, and they were especially a nuisance, at one time, seeing we had an intermittent supply, and that somewhat rendered cisterns necessary. Directly the water was turned on in one district the effect of it coming on again was that it disturbed it, and we never got clean water. A previous speaker has referred to taking water without registration, and I know it is quite possible to take water from these inferential meters without any registration at all. All you need do is to have a cistern and draw gently from it. With regard to the regulations I cannot say that they are required. If you have your meter, I cannot see that you require them. I think the nuisance of a meter is this—to take this 12*l.* rental—that the man will say to his wife, "You must not have so much water," and they use as a consequence dirty water and little of it. I have no more to say particularly on this subject, but I will mention one thing that I omitted on Thursday night in returning thanks for the kind manner in which my health was proposed. I have spoken to the Mayor, and I think it a great pity that such an arrangement cannot be made with all sanitary authorities, at all events that your annual meeting should not be more fully attended than it is. I think the Secretary should write to the respective boards and sanitary authorities, and call attention to the fact. I would go further, and say the sanitary authorities should devote a sum per annum to pay the expenses of those who attend, because it is for the benefit of

every sanitary authority that their engineers should be present at the gathering. They reap the benefit of the information he gets; you meet for the purpose of discussing the various subjects, which arise through the twelve months, and it must be for the benefit of sanitary authorities that they should be familiar with the discussion, and notwithstanding the voluminous report of the meeting, I think the cheapest way is for the respective officers to attend the Annual Meeting.

Mr. GORDON: I am sure, before I proceed to make any remarks on the question of the paper, we shall all feel indebted to Mr. Downing for his remarks. I believe he has touched the feelings of probably most Members present. The question of expense may not be such a very important matter to the surveyors of large towns, but it is highly desirable for the health of the towns that they should gather the information which I am sure every Member is able to get at these annual meetings. On the other hand, as far as the smaller corporations are concerned, I think if the sanitary authorities knew the value of the Members attending the meeting they would willingly arrange for them to do so, and if what Councillor Downing proposes was only suggested to the authorities they would most probably heartily agree to it, and at any rate bear the expenses of the Members attending the Annual Meeting. I am very glad to hear sentiments of that kind springing from a member of the local authority. With regard to the paper, although some of the questions which have been touched upon are very interesting, I do not think that a point to which our especial attention has been drawn by Mr. Winship has been sufficiently dealt with, and that is that the supply to the town is by means of a syphon, and I should like to have heard from him something like the amount of saving supposed to have been effected by its adoption. Probably Mr. Winship is not in a position now to give an answer to that, but I think it may be usefully recorded in our 'Proceedings' if he will supply it. There is a general impression that this syphon is being used for the first time in this way, but I think it is only right and fair to state that this is not the case. A Member of our own Association has already, I understand, executed a similar arrangement upon a somewhat larger scale, and it has been in action several years, and therefore we may feel some satisfaction in knowing that to a Member of our Association is due —whilst an eminent engineer has been engaged on this work—the credit of the first application of the syphon for supplying a town.

I mean Mr. Pritchard, and I think we should be glad to hear what he has to say on the subject, and to know what saving he effected in the use of a similar syphon in the town of Warwick.

Mr. PRITCHARD: I have great pleasure in making a few remarks on the paper, with which I have been much interested. I agree with Mr. Lemon that it is a difficult subject to determine the most economical means to supply water to a small town, and this appears to me a very creditable work. On two or three points I thoroughly endorse the remarks made by previous speakers. I object, in the first instance, to so small a quantity being delivered as six gallons per head per day; that is, if that is the only quantity. But I want to raise a further question. We are told that inferential meters are used, and we are also told by authorities on this subject —and there are none more competent to give an opinion than Mr. Downing from his experience of meters—and also Mr. Parker, that it is possible to obtain by a dribbling tap the volume of water you may require for daily use. We are told that 118 of these inferential meters are in use, but we are not told whether there is a meter on the supply main; consequently, is this six gallons per head a quantity to be relied upon? A meter placed on the main would give a fair value of the quantity passing through; but, on the other hand, the 118 meters, each with a dribbling tap, will not be a proper record of what, taken in the aggregate, is the volume of water passing through. I have had considerable experience of meters, and I have come to the conclusion that the Piston meter is the most reliable. I scarcely expect that this six gallons is a reliable data, and I shall be glad if Mr. Winship can inform us if he has some check on the meters. I fully endorse the remarks with respect to cisterns, and I think they are very objectionable, not only because of the deposit from the water itself, but because of sewer gas; and with Mr. Lemon I say every supply or service should be connected direct with the main. The cost of water appears to my mind a very serious consideration. The supply of a town like Warwick is 8*d.* per 1000 gallons, the maximum price, and the return represents something like 1000*l.* per annum. It is not a meter town. The principle of syphon action is something like we have seen to-day, but on a larger scale, and has been very successful. The prevention of waste, I think, can be brought about without the infliction of the great injustice of a meter on every consumer of water. If there is a meter on the main and an automatic record of the consumption at different times, day and night, and proper attention is given by the officer in charge

by means of sounding rods on the stop taps, there should not be any waste or consumption that there would be any difficulty in dealing with. The surveyor of Warwick, a Member of this Association, by careful attention to this question, has reduced the consumption of water in the town with an intermittent supply, from nearly 44 gallons per day to 19, and he has not put meters on the service supply. With regard to lead pipes, I have always looked upon what we term the middling and strong as being good pipes, the strong especially so; but I find in Abingdon the weights are given thus: ½-inch pipes, 6 lb. per lineal yard; ¾-inch, 9 lb.; 1-inch, 12 lb.; 1¼-inch, 16 lb. According to the scale of "light," "middling," and "strong," this is something like from 20 to 33 per cent. in excess of the "strong." It may be due to great pressure, but I should like Mr. Winship to inform us whether there is an alternating pressure on the pipes which requires such strength being given. That brings us to the point of supplying the town by means of a syphon, and I have great pleasure in this particular case to make allusion to the question of the syphon, inasmuch as before the construction of the syphon for Abingdon Mr. Bailey Denton conferred with me. He obtained from me information as to what had been done in Warwick, and he was so satisfied with the successful results for some years that he felt confident in introducing this unique system into Abingdon. I do not know whether the syphon at Warwick was the first that was introduced, but it was not contemplated in the first instance. It was intended to convey the water—four miles distant from the town—to the town by means of a pipe, but in consequence of the very difficult work and the very long tunnel, it was found absolutely necessary, in the interests of the Corporation, that some attempt should be made to minimise the cost. Probably it was not a wise thing for a young engineer to do, but I felt very strongly indeed that by the application of a syphon I should very much minimise the cost to the town, and the result has been most satisfactory during the six or seven years it has been working. The syphon saved the town as nearly as I can say from memory 3000*l.*, inasmuch as there was the difficulty of quicksand to remove, and that was a very difficult operation indeed. That is proved when I inform you that, to put in a pipe 20 feet below the surface it was found absolutely necessary to have a cutting equal to 49 feet to 50 feet in width at the top, and you will easily understand how a sum of 3000*l.* would be expended in work of that description. Personally

I feel obliged to Mr. Winship for the information he has given us, and I would ask him, before sitting down, to bear in mind to reply to the suggestion of Mr. Lemon, which is most important, and that is, the bend on the long leg of the syphon; there should be some means of preventing the accumulation of air at the summit, which would speedily arrest the action of it. That I consider most important, and at Warwick it was carefully attended to.

The PRESIDENT: I should like to ask Mr. Winship a question. I have not had time (and you can easily understand why) to go through this interesting paper in detail, but with regard to the construction of the reservoir and the house we saw, I should like to ask one or two questions, viz.: why it was considered desirable to construct the house and reservoir in concrete blocks; what was the cost of these concrete blocks (say per cubic yard); and what would have been the comparative cost of concrete built *en masse*, of building in stone, and also in brickwork.

Mr. WINSHIP, in reply, said: I am pleased at the manner in which the question has been discussed, and I am only afraid I shall not be able to do justice to it in replying, as, being deaf, I was obliged to get my notes taken for me. With regard to Mr. Lemon's remarks, there is an inverted syphon at the end of the long leg, and just below it is a large special air valve, and of course there is a sluice valve, which we can shut off when we want to fill the syphon. As to the observations respecting the small consumption of six gallons per head per day, I should like to say that the death-rate of Abingdon shows it has not had any serious effect, for I believe we have not had any deaths from zymotic diseases for the last eighteen months. I may remark, Mr. Hawksley says that Cambridge is the best regulated town in England, and the consumption there is 15 gallons per head per day. If, therefore, I take 15 gallons per head instead of 6 per head, I shall have 150,000 gallons per day to supply for domestic purposes only, taking 10,000 persons, which this supply is intended for, and I shall be drawing on the syphon more than half-way down, whereas now, through the winter, I manage every day without using the syphon at all. I quite agree with a minimum charge, and, in fact, I reported to the authority in favour of it. I do not at all wish to restrict the supply of water; that was the reason for reducing the price of the water a short time ago. Water is required for sewerage purposes and street watering, and previous to the construction of the waterworks we had to go to considerable expense for flushing. With

regard to storage cisterns, that clause was inserted in the Regulations as a sort of saving clause. We do not use cisterns generally, they are only recommended in one particular district at the highest part of the town, and it was thought desirable. In the lower parts of the town no cisterns are necessary. With respect to Mr. Parker's remarks as to whether we tried any other meters, I may say that I have had considerable experience with meters, and I do not like Kennedy's meters, for I know they must be attended to regularly. In fact, we have a Kennedy's meter on the main supplying the town, and that meter has often caused a lot of trouble. It is capable of passing a large quantity of water, but supposing there is only a small consumption, that meter will stop. I previously have been used to Guest and Chime's meter, but I prefer Tylor's. I have not heard of any swindling on the part of consumers in any part of the town by causing the water to dribble. In fact, if you get one year's consumption by meter from any consumer, you may take that as a fair test; and if in any quarter there is a sudden stop, you simply give instructions to have the meter tested; and if you have anything the matter, you can increase or diminish the flow by a screw arrangement; but if it is a serious defect, it must be sent to the makers. And, again, it would scarcely pay any consumer to purchase a large tank so as to let the water dribble into it, as the cost of the tank and fixing would exceed several years' consumption. With regard to waste-preventing cisterns, we do use them, but I think they are too small to cleanse and remove deposit where the main is more than 50 feet in length. I think they are sufficient for the closet, but not sufficient where you have long drains. The cost of the work was 9963*l.*, with a population of 6000 (but this supply is intended for 10,000): that would be about 30*s.* per head of the population. Mr. Hawksley says the total cost of gravitating schemes generally amounts to 5*l.* per head, so the cost of the work altogether must be considered very reasonable. Mr. White asked me a question with regard to the cost of the concrete blocks. The cost was 1*l.* 5*s.* per cubic yard, and made in the proportion of four of gravel to one of cement. I am sorry to say the analysis of the water has been mislaid; it was, however, exceptionally good. We have a pressure of 28 lb. to the square inch on the mains, and probably this is insufficient to work a very large Kennedy's meter; for, when a small quantity is passing through it, I find it will stop altogether. With regard to the amount of saving by the adoption of the syphon, instead of having to

excavate right out, I think it a very fair question of Mr. Gordon's. The fact is, the trench where the syphon is would be 26 feet deep at one end, and 11 feet at the other, for a length of 600 yards, or even more, and through solid rock. I should not like to say what the cost of excavating that rock would be.

Mr. PRITCHARD: I shall be glad if there has been any great saving effected by the syphon, and I should like to know whether the syphon was suggested by the Inspector of the Local Government Board, or whether it was the engineer's own suggestion?

Mr. WINSHIP: The syphon was first suggested by Mr. Harrison, the Government Inspector.

The PRESIDENT: You will all agree that we have had a very interesting discussion, and also that we are much indebted to Mr. Downing for his suggestion. I hope it is a suggestion that will bear fruit. It is within the knowledge of most of us that there is such an association as the Municipal Corporations Association. Most corporations, I believe, are represented in that association, either by the town clerk or by a member of the Corporation, or by both. I saw in a paper, the other day, that it had been resolved that an alderman and town clerk of a certain corporation should in future attend the meetings of the association in question. It was not said that their expenses would be paid, but there is a strong inference in that direction. I will not mention any names, but when a resolution like that is passed after solemn debate, we may fairly suppose the expenses would be paid. I consider, therefore, it would not be a very unreasonable thing to hope that our expenses in attending our annual meetings might also be paid by our Boards. I know that one Member did succeed in inducing his corporation to pay his expenses.

Mr. PARKER: That was my predecessor, and I am happy to tell you they keep up the custom.

Mr. Eayrs and other gentlemen rose and stated their expenses were paid.

Mr. COULTHURST: My expenses are paid, and I hope next year the custom will become universal.

Mr. CROSS: At Heckmondwike they not only paid the expenses of the gentleman attending, but his entrance fee and subscription every year.

The PRESIDENT: From the information that has been elicited, you will see that my remarks have not been made in vain. I think we cannot conclude without expressing our sense of the trouble

Mr. Winship has taken, and I have much pleasure in moving that we pass a formal vote of thanks to him for his paper.

This vote was duly seconded and carried unanimously, and briefly responded to by Mr. Winship.

Mr. LEMON proposed a vote of thanks to the Mayor and Corporation for the use of the Council Chamber. This was duly seconded and carried unanimously.

Mr. Councillor DOWNING replying, stated his pleasure in conveying the resolution to the Mayor.

Mr. GORDON proposed a hearty vote of thanks to the President for the very admirable manner in which he made the arrangements for the success of the meeting, and alluded to the manner he had conducted the business of the meeting as most gratifying to the Members. Mr. Vawser warmly supported this proposition, referring to Mr. White's untiring zeal in so courteously furnishing the Members with information. The proposition was carried with acclamation.

The proceedings then terminated.

On the evening of the first day the Members dined together at the Clarendon Hotel, Oxford.

On the second day the Members paid a visit to Magdalen Bridge, and inspected the works in progress there, which are described in the President's Address. Here the Members were photographed in a group by Mr. G. Coles, 161, *Cowley Road, Oxford, and subsequently left for the pumping-station and Sewage-farm, which they inspected.*

On the third day the party visited the Abingdon Waterworks, which were explained by Mr. Winship, and in the afternoon were conducted over the various places of interest in the University and city.

WARWICK WATER SUPPLY.

By Edward Pritchard, C.E.; F.G.S., Birmingham and London (Past President).

At a meeting of the Midland District Committee held at Warwick, on the 19th of April, 1876, a paper was read by the author on the above subject, but as at that date the works were in a state of incompletion, and in accordance with a promise made to the Members of the Association, at the Annual Meeting held in Oxford in 1883, the author now supplements the paper with further information relating to the supply, and also more particularly as to the construction of a syphon upon the supply main, rendered necessary as hereafter explained.

In volume iii. of the 'Proceedings' of the Association, and at pages 176 to 191, will be found a report of the proceedings of the District Meeting in question and the paper therein submitted. From a perusal of the paper, it will be found that in consequence of the very difficult nature of the subsoil at Hazeley, in connection with the construction of adits, considerable difficulty and great expense was therein incurred by the contractor for this work (Mr. G. F. Smith, of Milverton), and it is further explained therein that, as the contractor for the pipe laying (Mr. Charles Hart, of Leamington) having abandoned the work, Mr. Smith, by arrangement, became the contractor for the laying of the incomplete portion of the 12-inch diameter cast-iron main in the deep cutting near to Hazeley.

The following extract from the paper read at Warwick in 1876 will more clearly explain the reasons why it was considered necessary to stipulate for the sectional area of the excavation in the running sand:

"I have briefly alluded to the difficulties already experienced, and will simply give one or two illustrations, which will, I imagine, suffice. Although the extent of the works may have appeared small, still the contractor (to whom much credit is due for his perseverance) has been compelled to provide a plant of the value of nearly

2500*l.* for the execution of this work; the length of planking required and supplied for piles, barrow runs, &c., representing 41,500 feet, or nearly 8 miles. Again, to sink a sump 7 feet deep by 6 feet, equal 9⅓ cubic yards, 56*l.* was expended for labour only, being at the rate of 6*l.* per cubic yard. The cutting necessary for the laying of the 15-inch pipe, being 49 feet in width, although only a depth of 22 feet, will, I imagine, quite explain the fact that difficulties are being experienced."

To better illustrate the present paper, two sheets of drawings have been prepared, and a reference thereto will more clearly explain the description given.

Drawing 1: Fig. 1 shows a section of the pipe track from Hazeley to Warwick, a distance of nearly 4 miles. Fig. 2 shows a section (enlarged scale) commencing at Hazeley, and passing in the direction of Warwick, for a distance of 515 yards.

Drawing No. 2 shows details as to construction of pure-water tank and air-pumping machinery.

On the resumption of the works for laying the supply main to Warwick, the contractor commenced working at points A, B, and C (Fig. 1). A reference to the sections will show the stratification at these points as being in rocky marl, but on proceeding with the work, the contractor soon came upon a most difficult description of running sand. Although the work proceeded, under the exceptional circumstances, in a somewhat satisfactory manner, still the cost was so great that the author considered it desirable to suspend operations at points D and E and the intervening space; this he did, and the Corporation of Warwick, acting upon his advice, served the contractor with notice to vary the work, and instead of the construction of the main being in a straight line, as shown by dotted lines on section, a syphon was substituted, the short leg of the same being about 110 yards in length, the long branch representing about 1 mile in length; this syphon is of cast-iron socketed pipes, with lead joints, and is 12 inches in diameter.

The inlet to the syphon is in the pure-water tank, and formed with an ordinary bell-mouthed bend, jointed into the cast-iron pipe, and dipping below the invert level some 12 inches or thereabouts (see Figs. 5 and 6).

The vertical difference of level between the top of the syphon and the inlet to the syphon is between 9 and 10 feet, and the ordinary water level will probably be about 3 feet above the invert to the syphon, but this of course is a varying quantity determined

DRAWING N°1

WARWICK WATER SUPPLY

SECTION OF SUPPLY MAIN & SYPHON

E. PRITCHARD C.E.
WESTMINSTER & BIRMINGHAM.

FIG 1

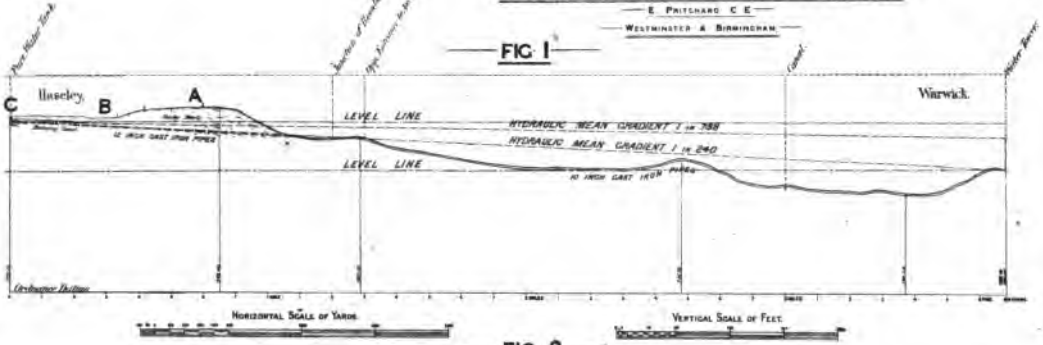
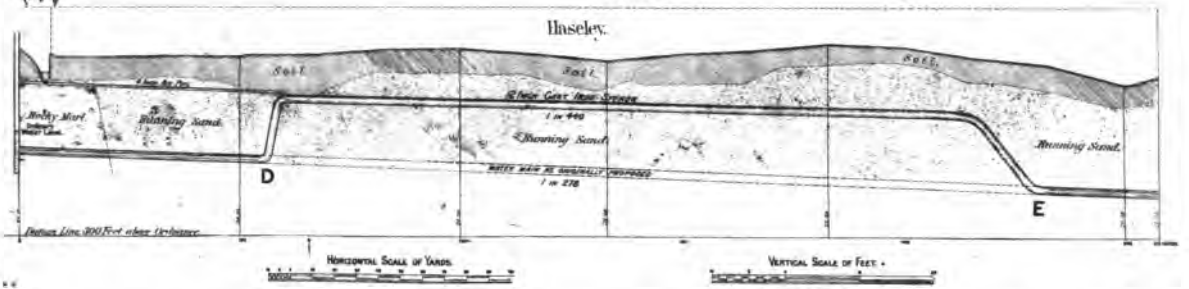


FIG 2

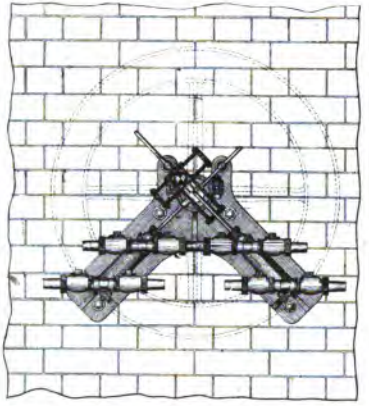


DRAWING Nº 2

WARWICK WATER SUPPLY

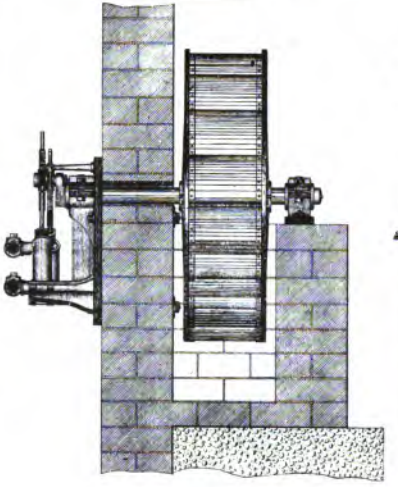
DETAILS OF AIR PUMPS & PURE WATER TANK

E PRITCHARD C E
WESTMINSTER & BIRMINGHAM



ELEVATION

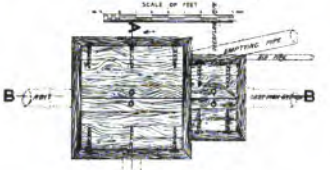
FIG. 3



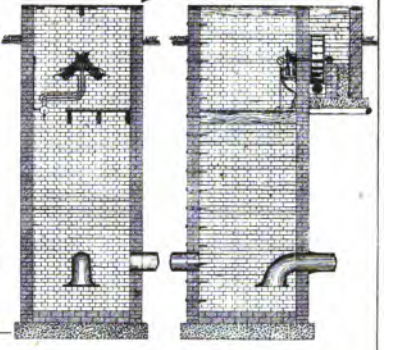
SECTIONAL ELEVATION

FIG. 4

PURE WATER TANK



PLAN



SECTION ON LINE A. A.
FIG 5

SECTION ON LINE B. B.
FIG 6

by the height of the springs and the draught upon the main; the water being only, in some instances, a few inches above the invert of the syphon inlet.

For the removal of air, which would naturally accumulate at the summit level of the syphon, a 4-inch cast-iron air pipe, with lead joints was carried back to the pure-water tank; and for the automatic removal of the air a neat design of pumps and water wheel was supplied, and the whole of the fittings manufactured, in a most satisfactory manner, by the Glenfield Company, Kilmarnock. This machinery is shown in detail in Figs. 3 and 4, in Drawing 2, and the following is a brief description thereof:—

The pumps are a pair of diagonal pumps with brass barrels. The pistons are of gun-metal, with a cup leather above and below (the pumps being double acting). The barrels are each set at an angle of 45° from the plumb of the crank shaft, and are worked by one crank pin passing through a bush in a slotted cross-head, of the ordinary donkey-engine pattern; the valves and chests are of gun-metal, metal to metal, of the conical form; access can easily be had to each valve as it is covered by a screwed cup and is in a separate chest. This crank is driven by a water wheel 3 feet in diameter, the sides or shrouding being of cast iron with ribs cast on to carry the buckets. The buckets were made of sheet brass. The small quantity of water required to work the wheel is obtained from the brook and is conveyed from a higher level through an earthenware pipe of small diameter.

Attached to the air pipe is a vacuum gauge, which indicates the presence of air at the summit of the syphon, and so renders unnecessary the constant working of the air pumps.

Although the normal water level is of necessity kept low by the constant draught upon the main, the water being supplied under constant pressure to the town, still with the sluice valves upon the main being closed, the water level in the pure-water tank would naturally be increased.

This syphon has now been in operation nearly seven years, and has so far worked satisfactorily; and although the risk in substituting a syphon for the original line as proposed was no doubt great, still, in the first cost there was a saving of nearly 3000*l*., whilst there is every prospect of a continuance of the satisfactory working of the syphon, and which, after so many years' working, would certainly appear to justify the author's departure from the somewhat hard and fast rule adopted, of having the line of supply

main so situated that in no instance shall it be placed at a higher level than that of the hydraulic mean gradient.

In conclusion, the author desires to state that in determining upon the substitution of a syphon for the straight line of pipe, he was unable to refer to any existing work of a similar description, and he is unaware of any such syphon arrangement having been previously adopted in connection with any similar work of water supply.

Memoirs of Deceased Members.

The Council, having been requested to append some short notice of the decease of Members of the Association, will feel obliged by early notice being forwarded to the Secretary, with such particulars as it may be desirable to insert in these 'Proceedings.'

It is with much regret that the Council have to chronicle the deaths of the following gentlemen, Members of this Association.

Mr. W. J. Boys, late Borough Surveyor, Walsall, died very suddenly on the 21st December, 1882.

The following extract from the 'Walsall Free Press' of December 23, 1882, gives a short account of Mr. Boys' professional career:

"Early on Thursday evening a fire was reported in Stafford Street, when with exceeding promptness the fire brigade and engine-men were on the spot, accompanied by Mr. Boys. The fire was already extinguished when they arrived. On the return Mr. Boys jumped off the engine, and entering into the house, fell unconscious into his daughter's arms. Medical aid was sought, and Dr. Maclachlan was soon in attendance, but his efforts were unavailing, and in a few minutes death ensued.

"The deceased gentleman was a native of Walsall, and was connected with one of the oldest families of the town. His father, Mr. John Boys, who still survives, has long been known as an extensive contractor and timber merchant, and other members of his family are largely engaged in business in the town. Educated at Queen Mary's Grammar School, for many years the late Surveyor was with his father, then with Mr. McLean, M.P., the distinguished civil engineer, and for a time lessee of the South Staffordshire Railway. In the year 1865 he became assistant to the late Mr. Clark, then Borough Surveyor, who, dying a few months afterwards, supplied the Town Commissioners with the opportunity of electing Mr. Boys his successor. For seventeen

years this position, with its daily increasing responsibilities and duties, has been held by Mr. Boys; and it is only weak praise to say that no man has better earned, or more unbrokenly received the increasing confidence of those who employed him.

"Under his father, he was connected with the making of the Walsall Reservoir, and then in canal work at Wyrley. Since he has been Surveyor of the Borough, he has planned the Bloxwich Cemetery; the extensive and well-ordered stabling in Goodall Street; the enlargement of the Free Library; the Borough Hospital; the storm-water sewer in Bridge Street; the subway in Bridgeman Street—a really fine piece of engineering work; the new streets over the Corporation land in Wednesbury Road; the bridge over the new mill's crossing; the deep sewer through the meadows; the Artizans' Dwellings Scheme on the Town's End Bank; the inauguration of the Fire Brigade, and last, but by no means least, the gigantic Sewage Scheme now in course of construction at Bescot."

Mr. James Gascoigne Lynde, formerly Surveyor to the Corporation of Manchester, died very suddenly at his residence, The Orchard, Greenheys, on the 15th March, 1883.

The deceased gentleman was the second President of this Association, and we can only add to the following brief account of Mr. Lynde's public life and career, extracted from the 'Manchester Guardian' of March 17, 1883, that we lose in Mr. Lynde a sincere friend to the Association, and one who will be long and deservedly regretted by all who knew him:

"Mr Lynde had attended to his professional duties at his offices in St. Ann Street up to Tuesday evening last, and with the exception of a slight cold was in the enjoyment of his usual health up to within a few minutes of his death. The deceased gentleman was a native of the south of England, and practised for many years as a civil engineer in London, as a member of the firm of Lynde and Sympson, George Street, Westminster. In 1857 he was appointed City Surveyor by the Manchester Corporation, which position he retained until his resignation in March 1879. During the long period Mr. Lynde occupied this position he was regarded by the members of the Corporation with the highest esteem and utmost confidence. Among the more notable undertakings carried out under his supervision were the widening of Deansgate, the improvement of the river Medlock, and the construction of the Corporation gasworks at

Bradford Road. He prepared the plans for laying out Alexandra Park, and more recently those for the Southern Cemetery; the Queen's Road Viaduct; the Sinerly Road Bridge, crossing the Irk; the Waterloo Bridge, which crosses the Irwell in Strangeways; the Irwell Street Bridge, in connection with the Quay Street Improvement; and the Prince's Bridge, which provides communication between Manchester and Salford by way of Hampden Street, Oldfield Road, were all constructed from his designs. Upon Mr. Lynde's resignation on the 4th of December, 1878, it was moved by the Mayor (Mr. Alderman Grundy), seconded by Mr. Alderman Lamb, and unanimously resolved, 'That this Council whilst accepting the resignation of their City Surveyor, Mr. James Gascoigne Lynde, recognise and appreciate the honourable motives which have induced him to take the step, and avail themselves of the occasion to record their sense of the ability, integrity, and zeal with which he has served the Corporation for a period of twenty-one years, and their best wishes for his future prosperity.' Since Mr. Lynde's resignation he has been engaged with his son, Mr. James Henry Lynde, in the profession of a civil engineer in this city. Mr. Lynde is one of the oldest Members of the Institution of Civil Engineers, having completed his fiftieth year of membership. Mr. Lynde was a Fellow of the Geological Society of London, and a Member of the Institute of Mechanical Engineers."

The remaining deaths are Mr. J. S. L. Downie, of Skelton, Cleveland, and Mr. George Thompson, of Derby.

LONDON: PRINTED BY WILLIAM CLOWES AND SONS, LIMITED, STAMFORD STREET AND CHARING CROSS.